Mars: NASA's New Mission

ASTRONOMY®

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The Hottest and Coolest Stars

How Galaxies Evolve

- Making the Most of a Cheap Telescope
- How to Survive Wintertime Observing

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12"
MEADE LX200 EMC
10"
MEADE LX200 EMC
7"
MEADE LX200 EMC
8"
MEADE LX200 EMC

LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models ***combined***. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of over 64,350 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning— from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an auto cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); complete operating instructions.

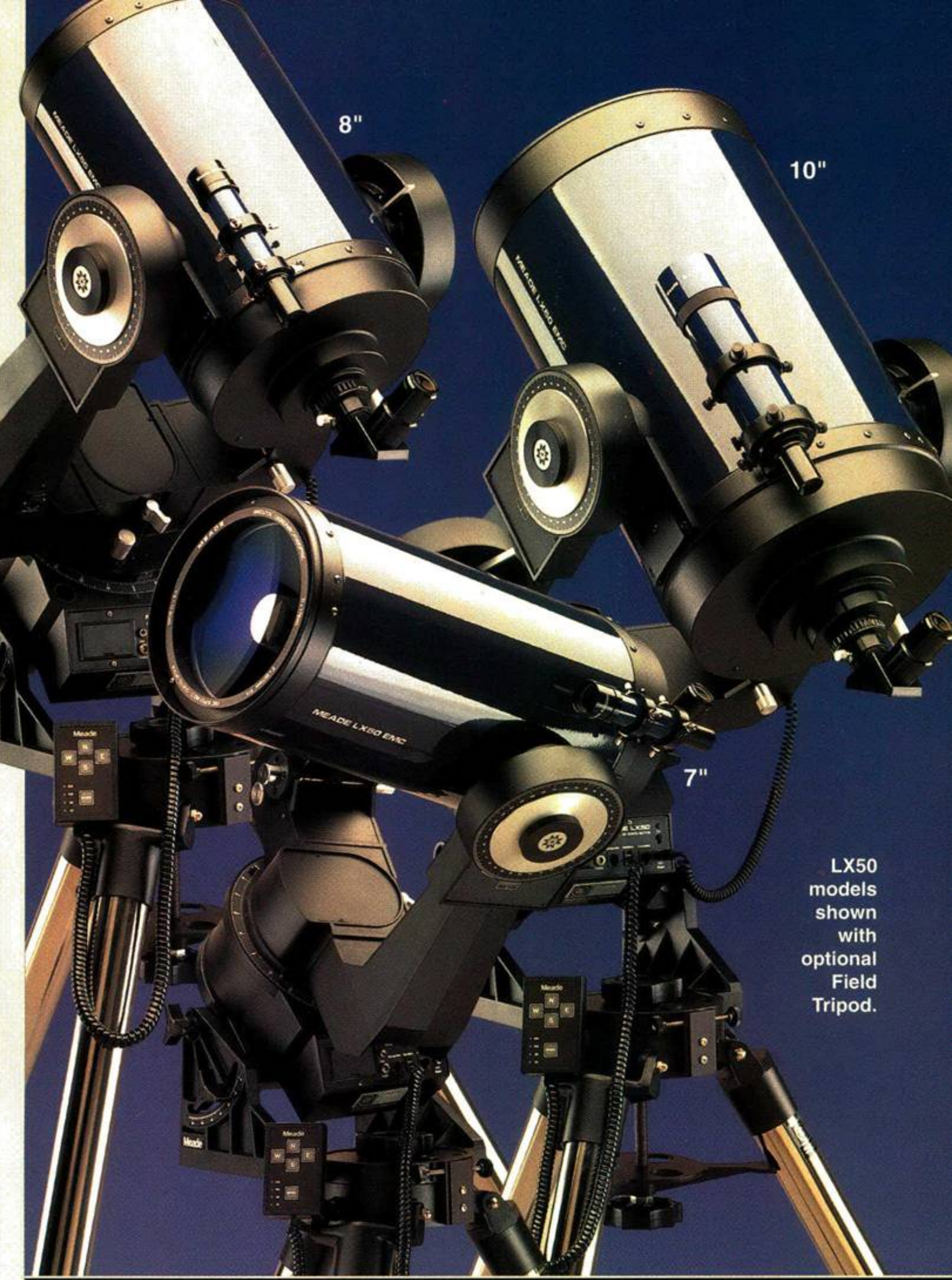
8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

ADE

LX50

Advanced technology at the most affordable prices ever.



LX50 models shown with optional Field Tripod.

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.
- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.
- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.
- **Super Multi-Coated Optics:** The exact same *EMC super multi-*coated optical tube assemblies included with Meade LX200 models.
- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

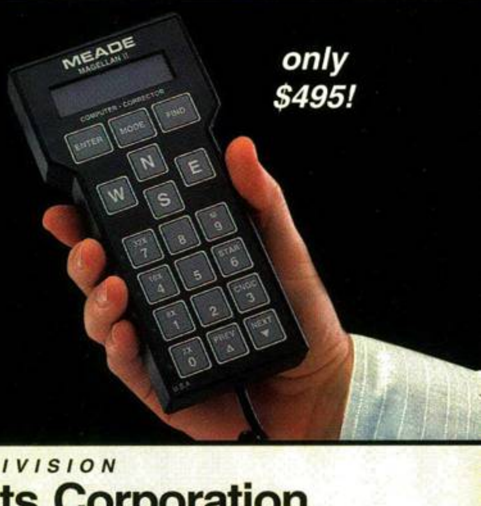
8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y, only	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Quick 2-star alignment. ■ Large 32-character, red-backlighted display. ■ 4-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

Write, call, or fax Meade Instruments for your free copy of the 94-page Meade 1997 General Catalog. Prices shown are suggested U.S. mail-order retail prices.



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Alan Dyer

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What Makes Galaxies Change?

Astronomers debate the age-old nature versus nuture question — are galaxies shaped by the properties they inherit at birth or by later encounters in their environment? *Marcia Bartusiak.*

Cover photo
European Southern Observatory

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74 Discover the Winter Sky
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BEHIND THE SCENES

Understanding a half-grown galaxy

Science is a process. That may be difficult to swallow, because most of us learn about scientific discoveries in headlines and news bites. We think of a breakthrough as the result of a singular epiphany that reveals itself to a lone thinker hunched over a laboratory bench — or maybe a computer. We forget that results grow out of work that can progress at a snail's pace and out of long, intense collaborations — or even out of angry bickering between competing scientific camps. Research is slower, more difficult — and often more tedious than most people recognize.

Hale Observatories

Many of my colleagues in science journalism set out to be scientists, then changed their minds. Some of them couldn't stand up to the single-minded nature of the task. They couldn't stand the long hours and unanswered questions, the repeated runs in the lab. Even writers long for simple stories, usually in vain.

On page 36, science writer Marcia Bartusiak tackles a big, complex story that has been in the making for about 60 years. It's the tale of how a galaxy evolves from its formation to something that resembles the Milky Way.

The veil has been lifted (though slowly) on this subject in recent years, with a lot of help from the Hubble Space Telescope. Hubble images have shown the galaxies halfway back to the birth of the universe. They have told astronomers a lot about how some galaxies have changed shape and how others have not. And the Hubble data have stood some long-held theories of galaxy formation on their heads.

Marcia's story is one that is especially rich in the process of science. It focuses on the work of six astronomers, scattered around the planet, who have joined forces to interpret the "blizzard of data" that Hubble has supplied. These people often have been competitors in the race for revelation. In this story, however, they are collaborators — working to piece together a single message from the many images Hubble has offered up.

Bonnie Gordon

Bonnie Gordon

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The Audit Bureau

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MEADE LX10 EMC
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Add the optional LX10 Declination Motor for dual-axis corrections at 2x.

Meade 8" LX10
Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

All the optical performance of Meade 8" LX50 and LX200 Schmidt Cassegrains...for only *$995!*

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *No other similarly-priced 8" Schmidt-Cassegrain offers such a range of standard features* — or such a range of important options for special applications. *Standard-equipment includes:*

Super Multi-Coated Optical System: The LX10 includes the *exact same* 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. Super multi-coatings (not available even as an *option* on competing 8" telescopes) are included with every LX10 optical system, for the highest levels of light transmission and image contrast.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. Ball bearings on the polar axis complement the precise action of the internal worm gear system.

Cordless, DC-Powered Electronic Motor Drive: A drive system that includes an electronically-regulated DC servo motor for automatic *sidereal-rate* tracking. The drive is powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4- pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions.
$995. (+ $65 packing & shipping in the 48 states)

LX10 Field Tripod	**195.**
LX10 Electric Declination Motor System	**85.**
#2014 Magellan I Telescope Computer System for LX10, with 12,218-object database	**375.**

The 94-page Meade 1996 General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers. Prices shown are suggested U.S. mail-order prices.

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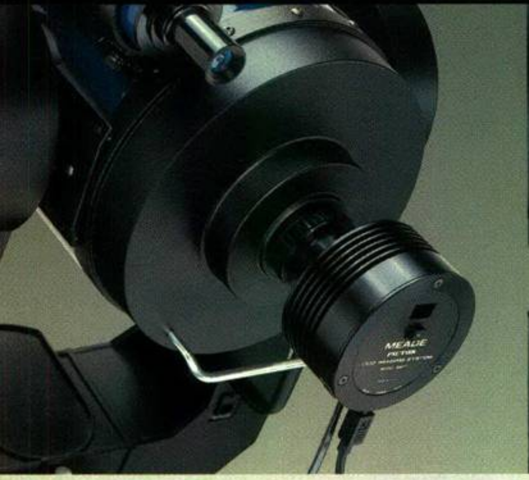
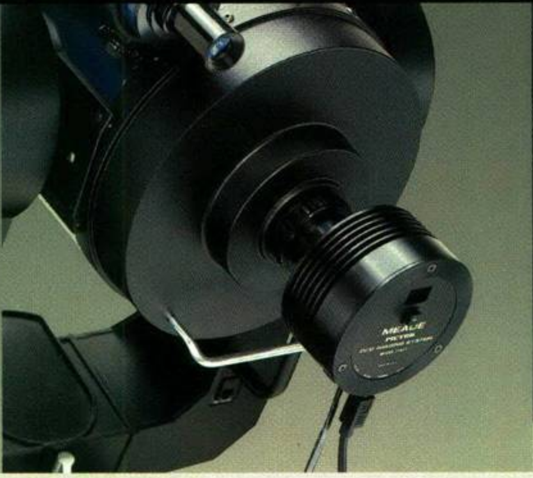
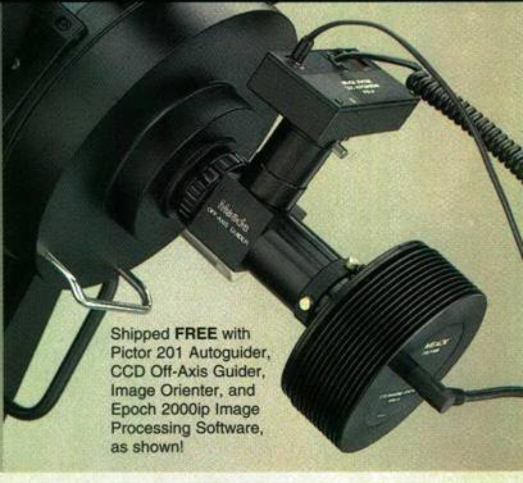
Meade Pictor 208XT
AUTOGUIDER/IMAGER
complete **$495**



Meade Pictor 216XT
AUTOGUIDER/IMAGER
complete **$695**



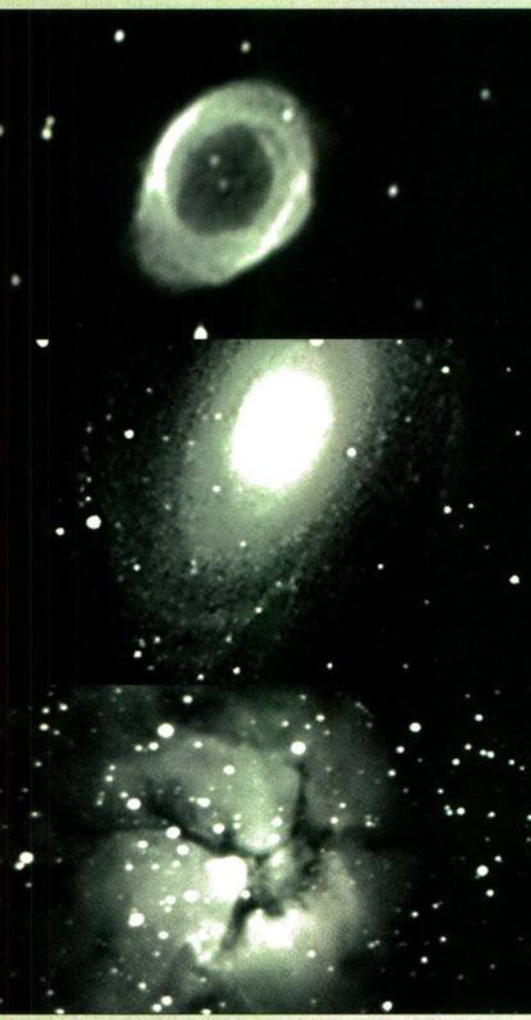
Meade Pictor 416XT
AUTOGUIDER/IMAGER
complete **$1695**
Includes $800 Meade CCD Equipment System



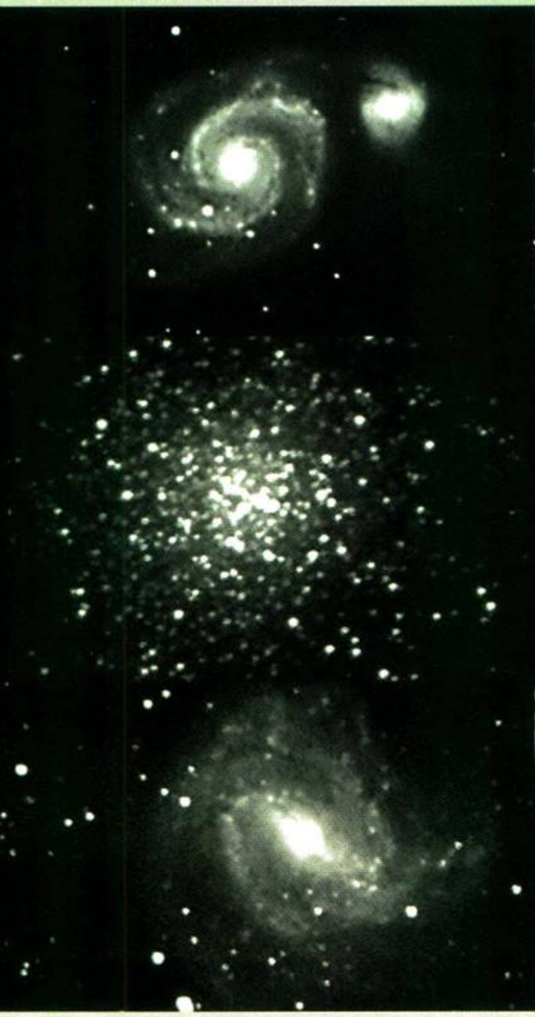
Shipped **FREE** with Pictor 201 Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

Revolutionary Meade Pictor CCD's are now the world's largest-selling autoguiders and imagers for the amateur astronomer. No other electronic imaging systems offer such an incredible range of capabilities at such amazing price levels. At only **$495** the **Pictor 208** produces on the PC display fine, high-resolution 8-bit images *in seconds* of the Moon and planets, or, in 2 or 3 minutes, of thousands of deep-space objects. At **$695** the **Pictor 216** enables advanced 16-bit imaging and is *by far* the finest autoguider/imager ever made available at under-$1000. At **$1695** the **Pictor 416** permits professional-level imaging capability for the amateur astronomer: an electronic camera capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes. All models are available for immediate shipment.

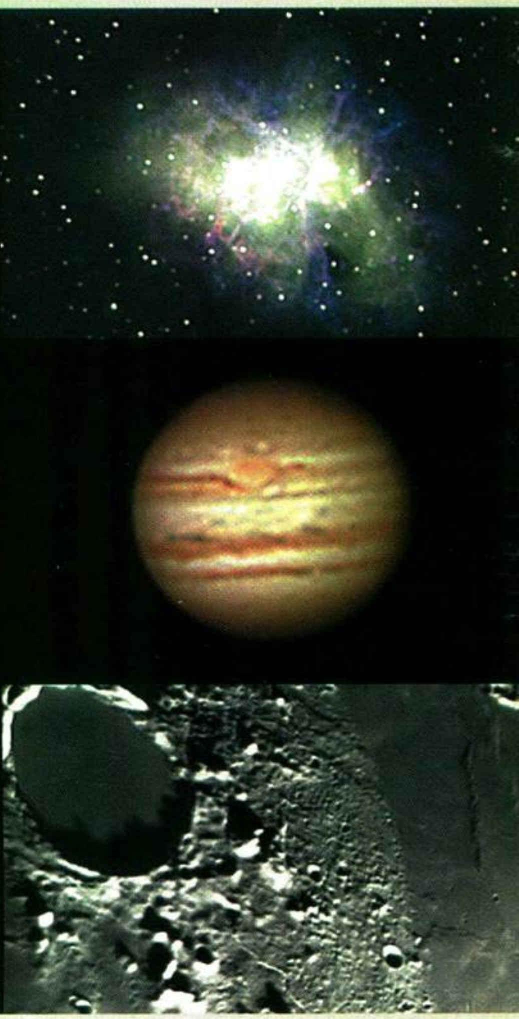
For complete information on Meade CCD imaging systems write, call, or fax for your free copy of the 94-page Meade 1997 General Catalog.



Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.



Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.



Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker.

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MEADE ETX

90mm Maksutov-Cassegrain

MEADE SUPER PLÖSSL
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Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope— Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* **$595***
(+ $20 packing and shipping in the 48 states)
*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$595*, *complete!*

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds,* just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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MEADE
STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right),* tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package
only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- **1 - Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- **1 - Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- **3 - Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

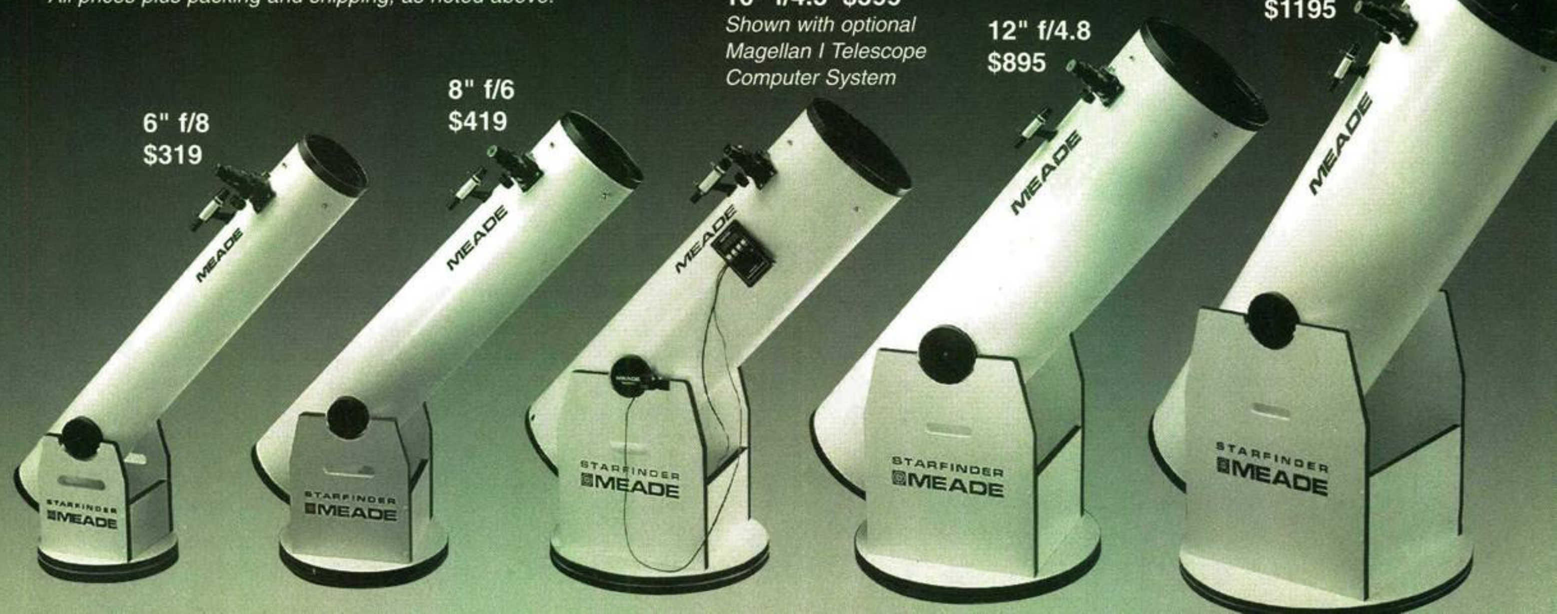
MEADE
ENTER
MODE
PREV
NEXT
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" .... $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***

All prices plus packing and shipping, as noted above.



6" f/8
$319

8" f/6
$419

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

MEADE
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DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

MEADE
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TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
COMPUTER—CORRECTOR
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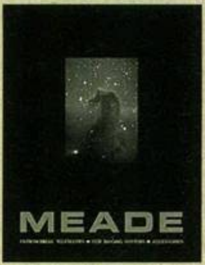
Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16". . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*



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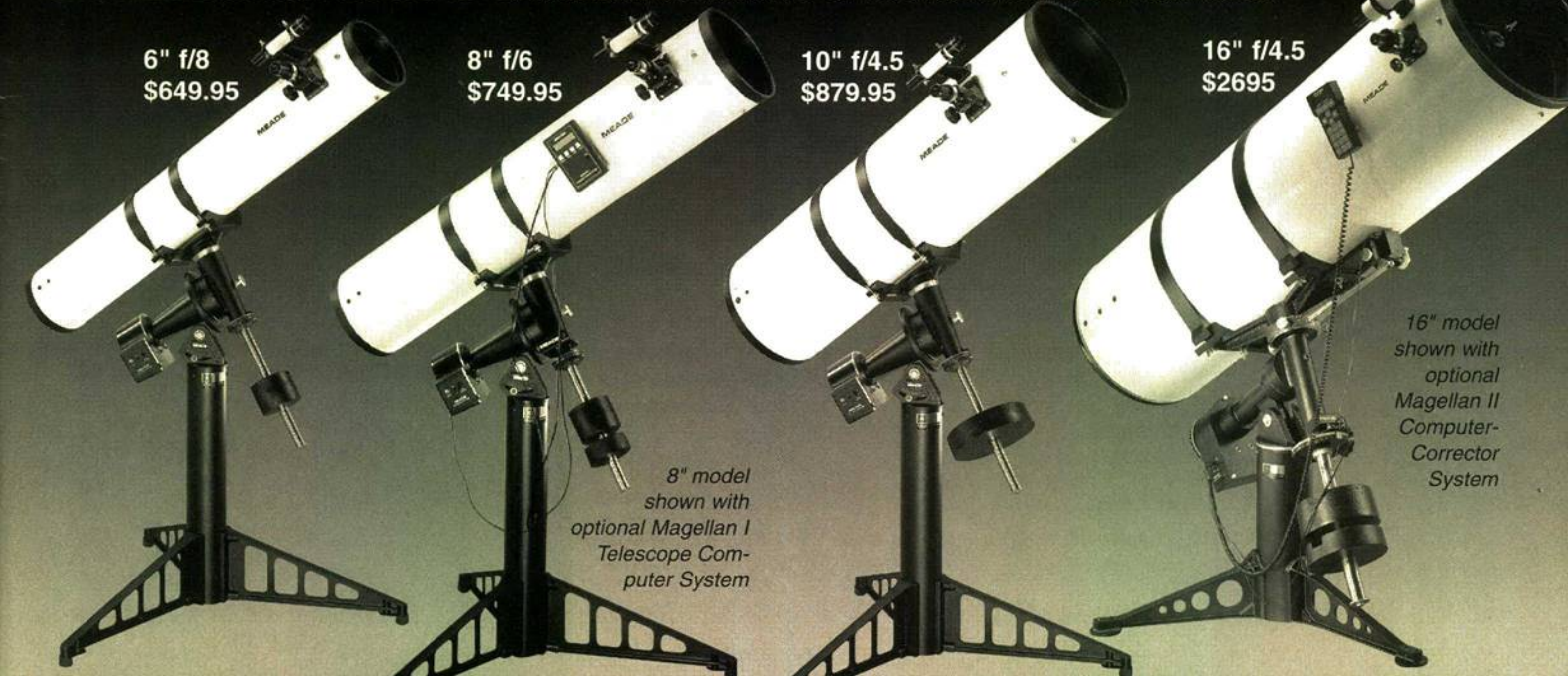
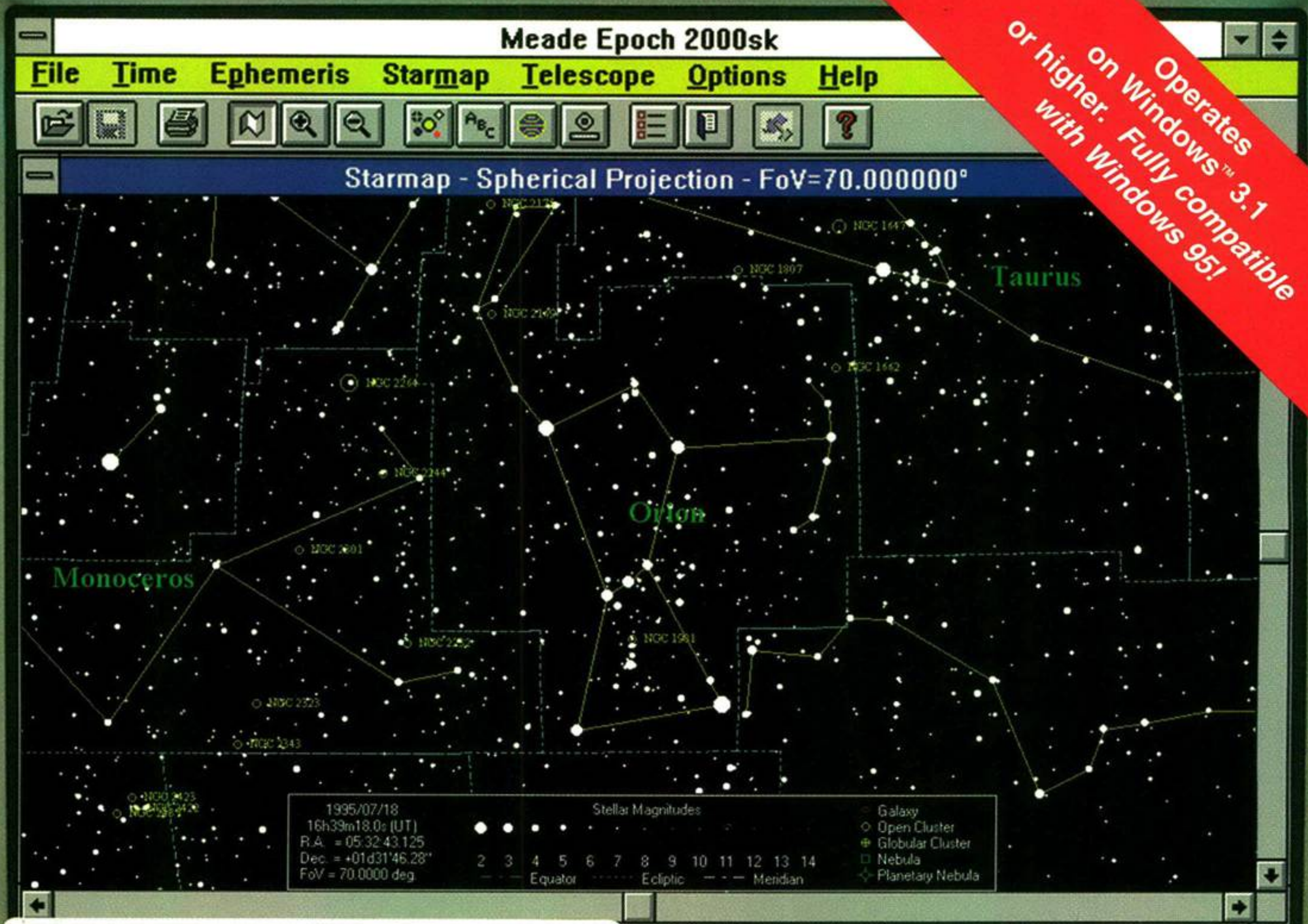
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

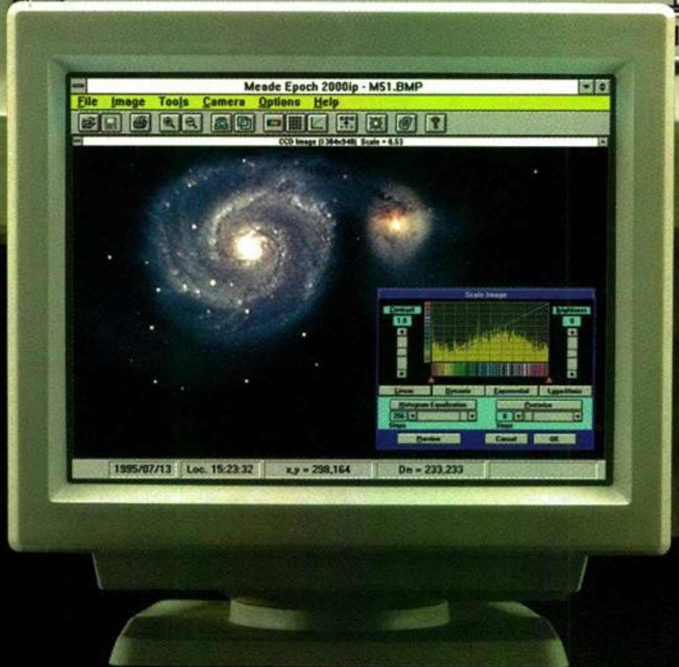
Operates on Windows™ 3.1 or higher. Fully compatible with Windows 95!


Meade Epoch 2000sk
File
Time
Ephemeris
Starmap
Telescope
Options
Help
Starmap - Spherical Projection - FoV=70.000000°
Taurus
Orion
Monoceros
NGC 2174
NGC 1647
NGC 1807
NGC 2169
NGC 1662
NGC 2264
NGC 2244
NGC 2301
NGC 2232
NGC 1981
NGC 2323
NGC 2343
NGC 2423
Stellar Magnitudes
2 3 4 5 6 7 8 9 10 11 12 13 14
Equator
Ecliptic
Meridian
Galaxy
Open Cluster
Globular Cluster
Nebula
Planetary Nebula

1995/07/18
16h39m18.0s (UT)
R.A. = 05:32:43.125
Dec. = +01d31'46.28"
FoV = 70.0000 deg.

15:32:34 | R.A. 01:09:39.072 | Dec. +05°55'44.61"

Epoch 2000sk *(above)* displays stars, planets, asteroids, and comets accurate in position to an *arc-second* level, the most precise position display of any sky software yet developed.


Meade Epoch 2000ip - M51.BMP
File
Image
Tools
Camera
Options
Help
Scale Image
Preview
Cancel
OK

1995/07/13 | Loc. 15:23:32 | x,y = 298,164 | Dn = 233,233

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52° field; multi-coated

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Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95**	(3.45)
32mm (52°); **40mm** (44°)	each:	**99.95**	(3.79)
56mm (52°; 2")		**199.95**	(5.48)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5° at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

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2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

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Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95**	(2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95**	(2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95**	(2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

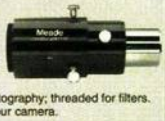
.965": **$27.95**; 1.25": **$29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls 50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

#911B
#910B
#908B
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Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95**	(3.45)
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#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95**	(3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95**	(3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95**	(3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

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- Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

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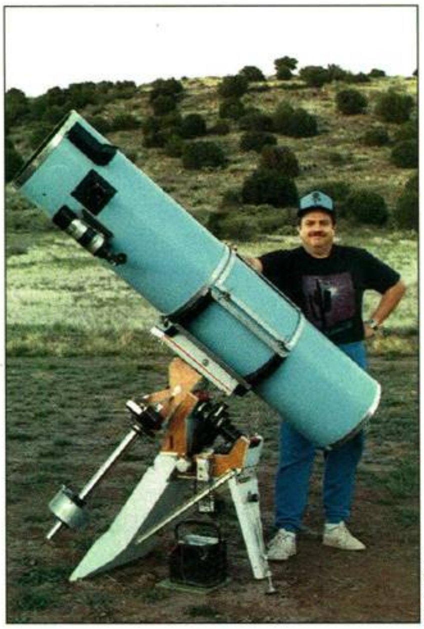

Steve Coe

Steve Coe of Phoenix, Arizona, displays his 13-inch Newtonian, which incorporates many ideas that were published in ASTRONOMY.

Big Difference in Light-Tight Scope

Over the years I've added many of John Deitz's improvements ("Make Your Scope Light-Tight," September 1996) for reducing stray light in my 13-inch f/5.6 Newtonian telescope. I have found that these additions make a big difference in the amount of detail I can see on the planets and within nebulae. As John wrote, each small improvement is a step along the way to having a telescope that produces excellent images with high contrast. — *Steve Coe, Phoenix, Arizona*

Where's the Kydex?

A number of readers have written and called concerning the availability of Kydex, a flexible material that works well for dew caps and glare shields ("Make Your Scope Light-Tight," September 1996). *For the nearest Kydex distributor, call (800) 626-2181.*

Simpler Solution for the Starhopper

ASTRONOMY's review of Celestron's Starhopper Dobsonian ("Sizing up Starhopper," October 1996) suggests moving the secondary mirror and installing a shorter focuser as a cure for insufficient illumination of the focal plane. A far simpler solution is to drop the primary mirror back an inch or so while ensuring that one's eyepieces still reach focus with the focuser racked most of the way in. — *Gary Seronik, Vancouver, British Columbia, gseronik@direct.ca*

Cheers for ASTRONOMY Artists

Some time ago a letter to ASTRONOMY protested the inclusion of art in this age of magnificent real thing image recording. The real thing is well impressed on the mind by Lynette Cook's symbolism about where we stand in the face of the dark matter mystery (October 1996). One day the adhesion keeping the large scale universe together may be understood, but for now, a cheer for the imaginative artists who help us to visualize it.

ASTRONOMY's way of keeping in touch with the human ingredients of puzzlement, awe, and inspiration, while scientists discover and explore, is on the mark. — *Edward Martin, Buffalo, New York*

Try This Photo Method

After reading "Fish-eye on the Sky" (August 1996), I was inspired to tell you about another cheap method of obtaining wide-field sky photos. I use a negative 10-inch diameter fresnel lens mounted in front of an SLR camera with a 55mm f/1.4 lens. Then, I mount it on a cardboard frame and bolt it to an L-shaped metal rod. The camera is attached to the other end about eight inches from the lens. This assembly is attached to the viewfinder rings on my telescope for guided exposure photographs. The image brightness is reduced by about 50% and the view is unobstructed. — *Edwin C. Perley, Yutan, Nebraska*

Sidewalk Astronomers Invade Europe

On August 11, 1999, for the last time in this millennium, the Moon's umbral shadow falls on Earth; cross-ing much of Europe. The San Francisco Sidewalk Astronomers will be touring Europe with telescopes in tow. Join our intrepid group on this epic quest of enlightenment. A summer odyssey of sightseeing and stargazing awaits you. For more information on Euroclipse '99, send a SASE to Euroclipse '99 Information, 1775 42nd Avenue, San Francisco, California 94122-4005.

Come out and play — your idle telescope mocks you! — *Barry Hirrell, San Francisco, California*

United States Still in the Lunar Window

"Lunar Windows to the Heavens" (September 1996) inspired me to advise you that NASA, as part of its Advanced Missions Concepts and other programs, is funding our group at the Goddard Space Flight Center to investigate a first generation unmanned telescope on the Moon. Such a telescope, which can be deployed robotically within several years, is an ultra lightweight, "smart" ultraviolet-visible-infrared imager and two-beam interferometer. The projected cost is between $30 million and $50 million, about that of a NASA Small Explorer Class Mission. It could even be funded by private foundations or wealthy individuals.

Readers can find out more details on our web site at http://snoopy@gsfc.nasa.gov/~lunartel/lunar1.html. — *Peter C. Chen, Computer Sciences Corporation, and Ronald J. Oliversen, NASA Goddard Space Flight Center, Greenbelt, Maryland*

Dark Matter Mystery

Robert Naeye's article "Ghosts in the Cosmic Machine" (October 1996) raises a question. If, as the article states, "gravity enables the slow-moving WIMPS to clump together into enormous clouds," what prevents those clouds from undergoing gravitational collapse to form condensed, luminous objects? — *Lee Helms, Rochester Hills, Michigan*

Gordon Kane, who is quoted in the article, responds, "It's that WIMPs won't interact enough or in the needed

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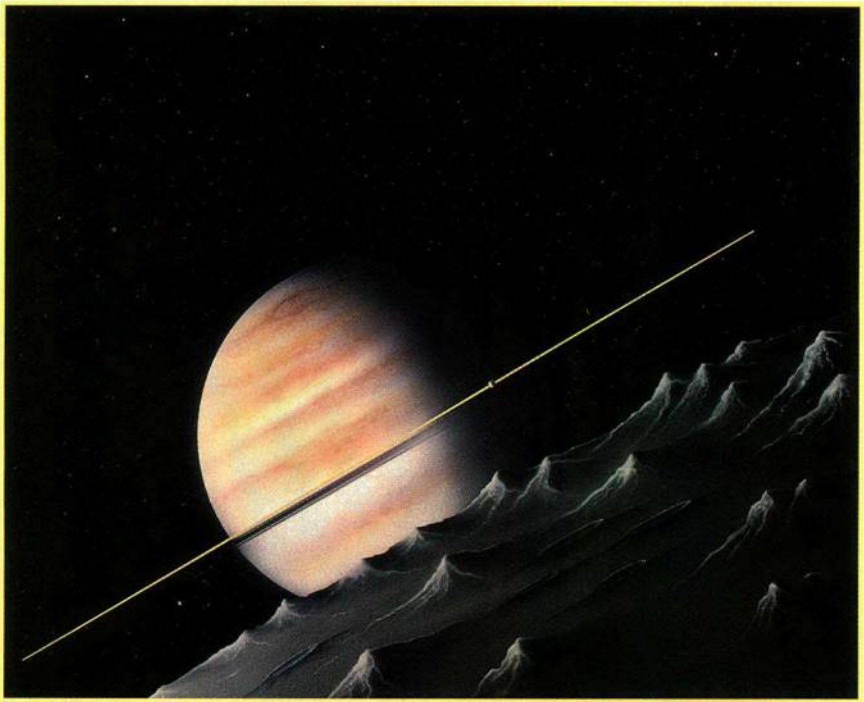

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ways. Luminous means they emit lots of photons. The 'baryonic' matter, protons and neutrons, goes through nuclear and other processes that burn hydrogen and end up as helium nuclei. There is no such thing for the WIMPs. They do interact, but mainly to annihilate into other particles, and give very few photons. So a dark matter 'star' would not be luminous."

Home Sweet Home

During my 13-year old-daughter's recent visit, I showed her some planets through my 10-inch telescope.

While still daytime I showed her Venus, then pointed it out so she could see it naked eye, which she thought was pretty neat. She looked at Jupiter later that evening and was amazed at the cloud bands and Galilean moons. Then came Saturn and its rings to which she said, "Oh, cool, Dad!"

After seeing these amazing views through the telescope, I asked, "Jackie, what's your favorite planet?"

She replied, "Earth." — *Richard Nugent, Houston, Texas, rnugent@ghgcorp.com*

Whitecloud Satellites Fooled Some Readers

Thank you for reporting on the trio of "Whitecloud" satellites (November 1996).

During a Perseid camping trip to Montana, I unknowingly observed these satellites passing through the constellation Delphinus. I had never heard of satellites moving in formation and these did not seem like airplanes, because there were no flashing lights. Frankly, I thought my eyes were playing tricks on me. After reading your report, I made the assumption that the Whitecloud satellites were 100 miles from my location and because I was able to estimate the angular size of 2°, which is about the size of Delphinus, these satellites were separated by at least 3.5 miles in space. — *Jim Powers, San Bruno, California, jlpowers@best.com*

River Shakes up Paradigms

I'm concerned about the sureness many astronomers portray when speaking about the origin and structure of the universe. It's about time an article like "A River in the Universe" (August 1996) came along and shook up established paradigms. Perhaps the cosmos is grander than we imagine. — *William F. Cade, West Point, Mississippi* □

ASTRONOMY welcomes feedback. Send it to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet use letters@astronomy.com. Letters may be edited for space and clarity.

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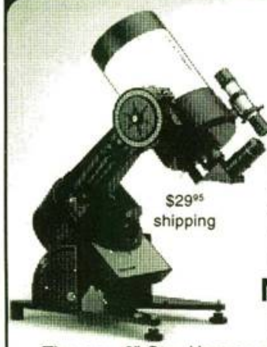

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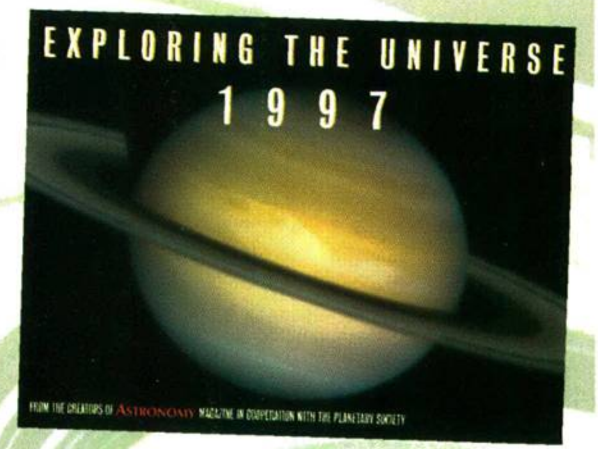
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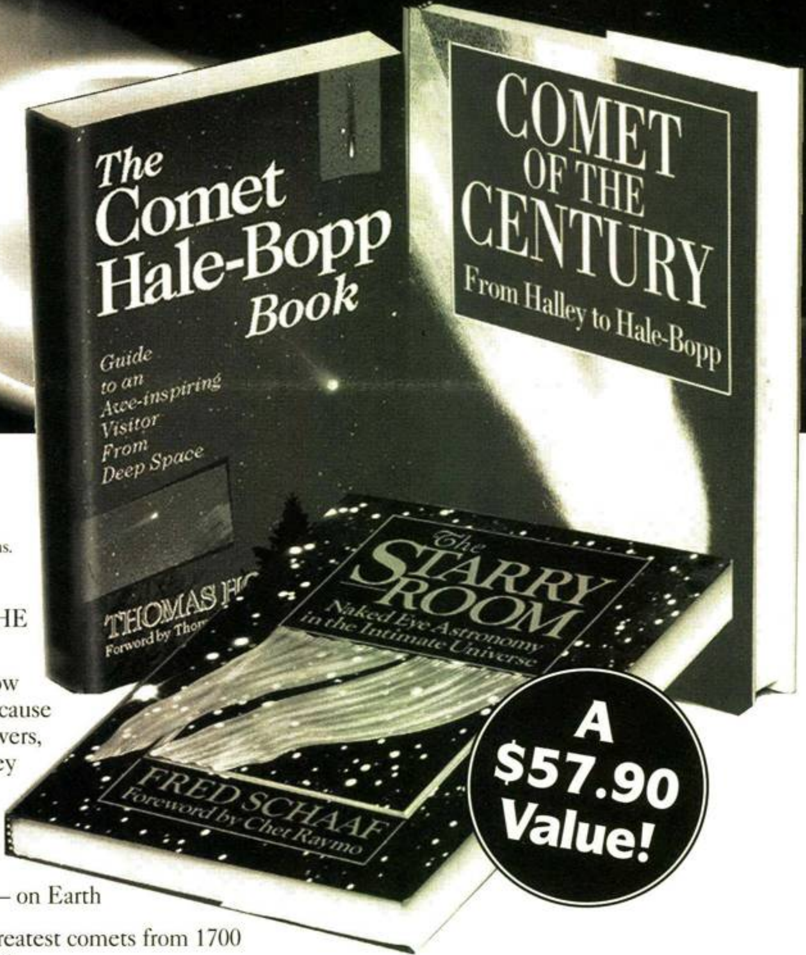

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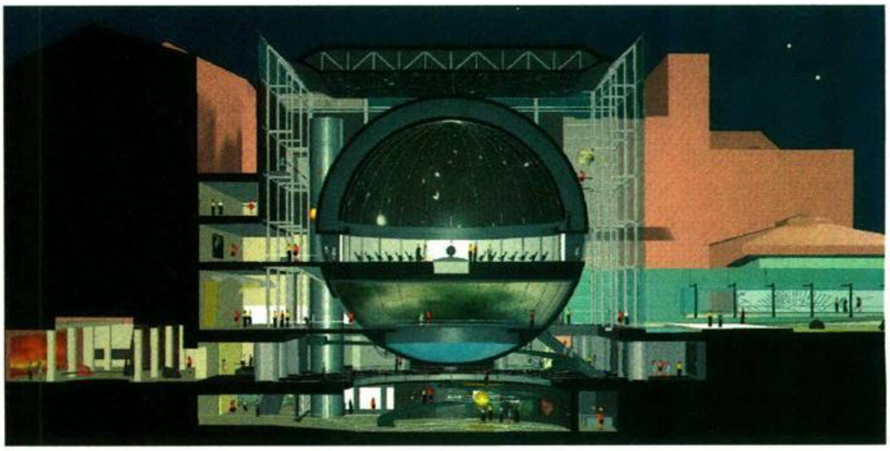

Polshek and Partners Architects

This cut-away view shows a proposal for the new design of the American Museum–Hayden Planetarium and surrounding exhibits.

Renaissance or Regret?

by Claudio Veliz

Astronomers are sensitive to issues affecting public education. Unfortunately, education is now moving toward a dangerous simplicity. This "dumbing down" of our society is creating an upsetting trend: public educational institutions earning revenue by peddling titillation: what feels good, period.

Many planetaria, the places where the general public encounters astronomy, seem to find it easier merely to entertain audiences rather than engaging them with substance.

The tendency now is toward the conversion, in many large planetarium programs, to laser rock-and-roll and science fiction exhibits displacing a pursuit of excellence in scientific, educational content. Or worse, some are blurring the distinction between science and fantasy in the name of securing profits through entertainment.

Entertainment satisfies a hunger and thirst. Animals get hungry and thirsty. Education, however, is supposed to inspire. It is the propellant of successful civilizations. Carl Sagan's book *The Demon-Haunted World* (Random House, 1995) addresses these issues in a compelling way. He quotes Epictetus, the Roman philosopher and former slave: "We must not believe the many, who say that only free people ought to be educated, but ... rather believe the philosophers who say that only the educated are free."

Now, as a case in point, we hear that a noble lady is about to be replaced. The Adler Planetarium in Chicago, the Griffith Observatory in Los Angeles, and the American Museum–Hayden Planetarium in New York are among the sancta sanctorum in the realm of scientific education for the general public. It is no trivial symbol that we are about to bid one of them goodbye.

The American Museum–Hayden Planetarium is to be demolished this winter and replaced by what the museum administration claims is a new, improved version to open by New Year's Day 2000. Why? According to Landmark West, a preservation group in New York City, "The draft environmental impact statement implies that dwindling attendance at the planetarium is due to its being 'out of date' without recognizing that it has not been maintained and that no effort has been made at keeping it current."

The Hayden Planetarium is not so much out of date as abused. It has been left to deteriorate for many years under previous directors. During much of that time, in the name of maintaining profits, rock-and-roll laser shows became one of its staples on weekends instead of stimulating

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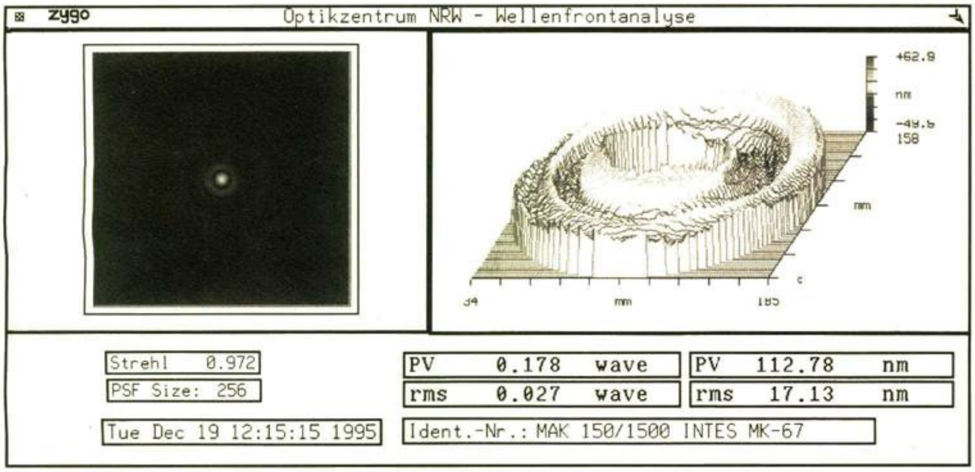

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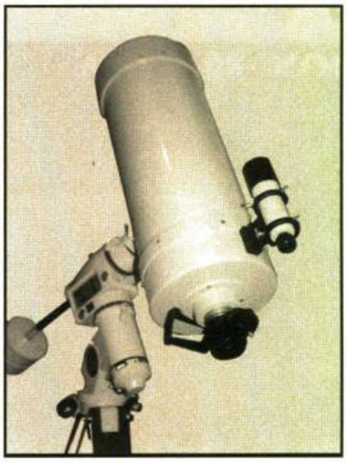

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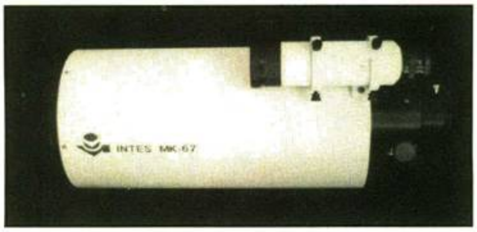

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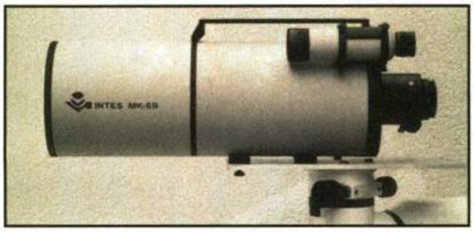

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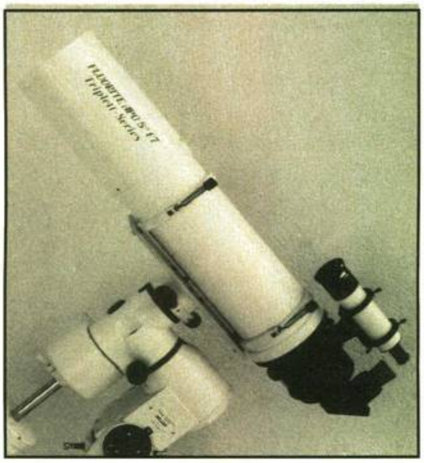

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astronomy programs. So infamous was this appalling situation that an essay in the *New York Times* by Ken Kalfus about the planetarium became the catalyst for the book *Dumbing Down: Essays on the Strip-Mining of American Culture* (Katherine Washburn and John Thornton, editors, Norton, 1996). Is there hope that the same museum administration may want to make amends?

If public education is the fuel of civilization, then surely a prime ingredient of that fuel is a reverence for history, the tracing of past events, and their contributions to the present. Given the emotional attachment Americans have to the Hayden structure, why not renovate it and incorporate current, state-of-the-art technology that conveys inspiring information about our universe? This was accomplished at the Charles Hayden Planetarium in Boston and at the Buhl Planetarium in Pittsburgh.

According to the planners with whom I spoke, renovating was impossible. From the start, there was a growing wave of professional advice, culminating in an acknowledgment of what was felt to be an obvious solution to the program directives: replace the original building. However, no one asked the experienced planetarium staff for advice, nor was the public at large seriously consulted, as is typical for a project of this magnitude intended for public use.

But not all is suspect. The new design created by the firm Polshek and Partners Architects is dramatic. The firm is demonstrating its capability in building this type of structure, which is elegant and user-friendly. Standing on the same location as the old Hayden, the proposed structure is a sphere containing the new planetarium and a "Big Bang" hall below, with walkways wandering about the perimeter — all in a faceted glass box.

To its credit, the new museum will contain the paraphernalia to convey the universe in a connected manner, a concept lacking in many institutional plans. Among the state-of-the-art features will be a real-time bulletin board that pipes in images of

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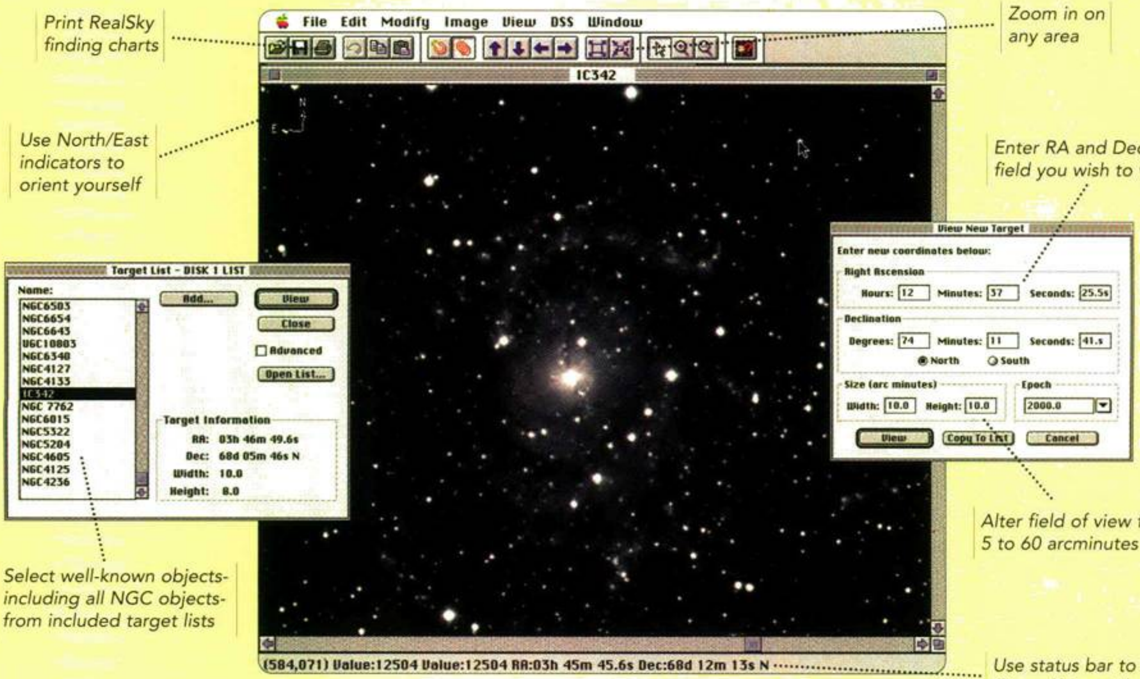

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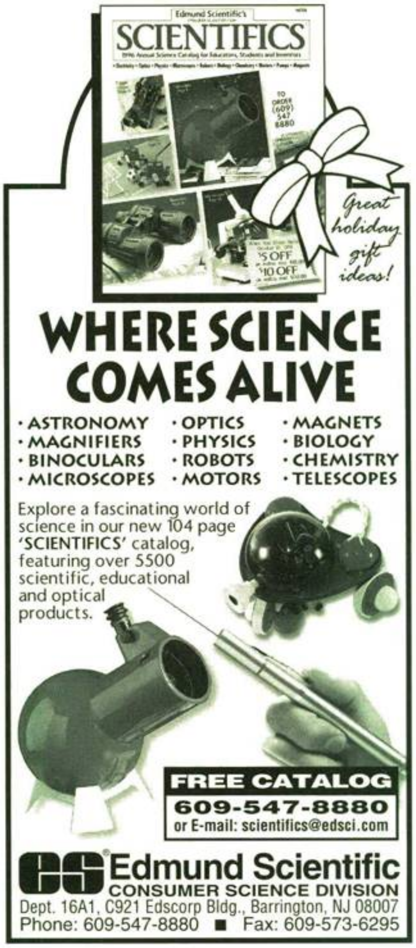
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Claudio Veliz

Will education be sacrificed when New York's Hayden Planetarium is replaced?

current space and astronomy activity. For example, an audience will be able to watch live images from Mars rovers as they roam the planet's surface, presenting landscapes all will see for the first time.

With the animated, politically savvy new director, Neil De Grasse Tyson at the helm, this ship might sail. He does seem sensitive to this concern of exploitation through mere entertainment, eager instead to establish the new Hayden Planetarium as a beacon of public astronomical education and research.

Tyson and his crew have a profound opportunity to contribute to the American educational landscape. Along with the museum planners and architects, they will carry a responsibility stretching far beyond the elegant glass walls enclosing the planetarium sphere. From afar, we will all see through to the larger challenge.

They will have to justify, convincingly, the loss of a stanchion of memories of joyful, substantive scientific education. Is this new structure going to set a course that, through hype, flash and mere entertainment, becomes a symbol of efficient exploitation in our society's quagmire of scientific ignorance? Or, alternatively, will its glowing sphere and elegant design inspire other institutions to follow a new course toward vivacious, exciting scientific literacy? We shall all be watching, closely. ☐

Claudio Veliz is a New York architect and serious amateur astronomer. His article "Mars on Earth!?" appeared in the November 1996 issue.

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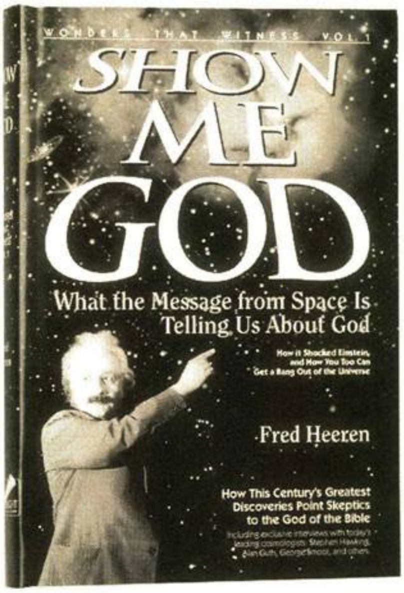
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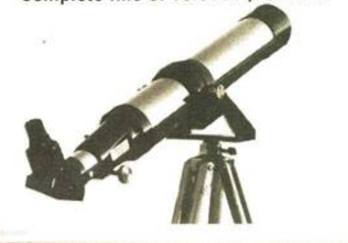

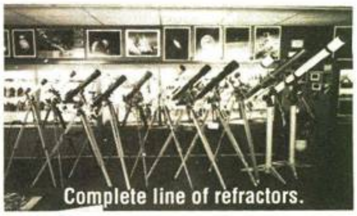
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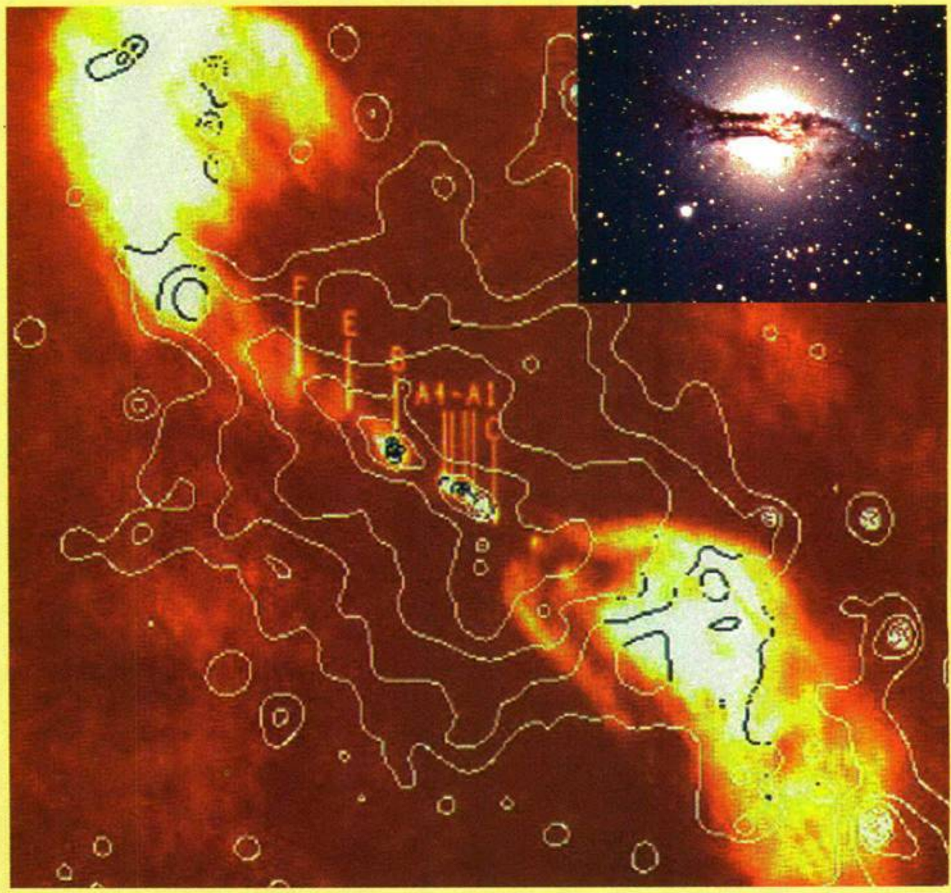
Galaxies Formed Sooner than Thought

Information continues to pour in suggesting that galaxies formed when the universe was only a few billion years old, much sooner than many theories have predicted.

The most recent evidence involves extremely faint blue galaxies that have turned up in long exposures of deep space. Astronomers knew these galaxies were far away, but they didn't know how far. To find out, a team of astronomers at the University of Durham in England, led by Nigel Metcalfe and Tom Shanks, examined some of these galaxies that appeared in the Hubble Space Telescope's Deep Field. They imaged others with the 4.2-meter William Herschel Telescope in the Canary Islands and the

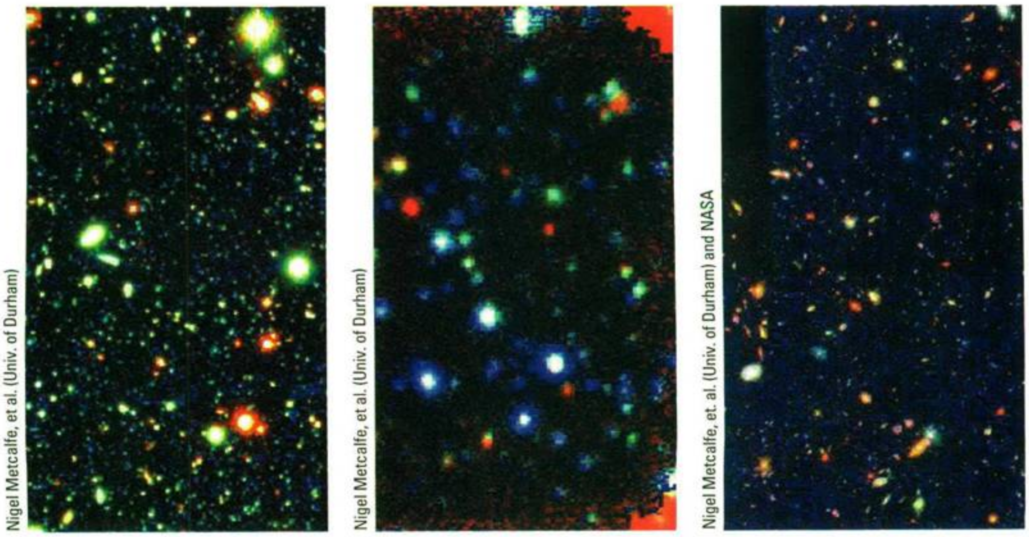


James R. Foster

S. Döbereiner (Max-Planck-Institut), et al.

The nucleus of the nearby active galaxy Centaurus A doubled its X-ray luminosity between 1990 and 1994. This image shows that the galaxy's X-ray brightness (seen as contours) closely matches its radio output (the underlying image). Several bright knots, whose brightness did not vary, mark an X-ray jet that runs to the upper left of center. The study also turned up about 30 point sources of X-rays in the galaxy.

Three telescopes show faint, blue galaxies caught in the act of formation. On the left is a 50-hour exposure in blue light taken by the William Herschel Telescope. A 30-hour infrared exposure from the U.K. Infrared Telescope is in the center — it shows a small portion of the field imaged by the Herschel Telescope. On the right is the Hubble Deep Field, which combines infrared, visible, and ultraviolet light. By determining galaxy colors in these three images, astronomers could estimate the galaxies' distances, which in turn tells them that the galaxies were forming soon after the Big Bang.



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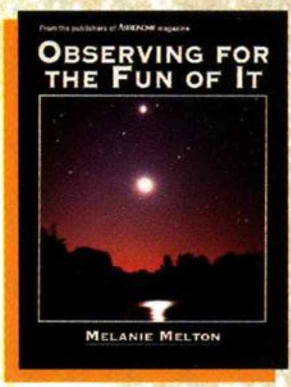
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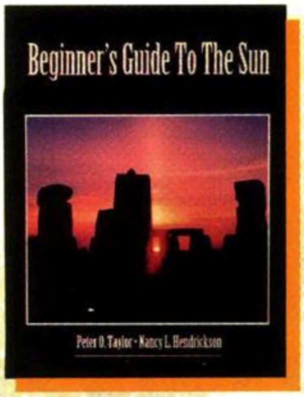
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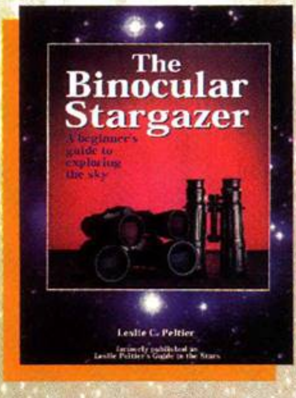
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To find out how far away a distant galaxy is, astronomers normally measure how much its light is shifted toward the red end of the spectrum due to the expansion of the universe. But these galaxies are so faint that there's not enough light to obtain their spectra. The Durham team took advantage of the fact that each of the images they had was from light in a different part of the spectrum. By combining the observations, which ranged from the ultraviolet to the infrared, the team was able to estimate how much the galaxies' light has been shifted toward the red. From this, they were able to calculate how soon these galaxies formed after the Big Bang.

The galaxies turn out to be much farther away than astronomers had estimated, although not as far as the most distant galaxies and quasars. But they must have been forming at a time when the universe was only 20 to 30 percent of its current age.

Eccentric Planet Discovered

The menagerie of extrasolar planets keeps getting stranger and stranger. The newest addition is a planet that orbits a virtual solar twin in a stretched-out ellipse, an orbit far more elliptical than that of any known planet inside or outside our solar system. The planet has a mass of at least 1.6 Jupiters and orbits the star 16 Cygni B, a magnitude 6.2 star 100 light-years away.

The planet's 2.2-year oblong orbit brings it as close as 0.6 AU from the host star, a little closer than Venus' distance from the Sun, and out to 2.8 AU — well beyond Mars' distance. "This planet will have wild seasonal variation," notes co-discoverer William Cochran of the University of Texas. If such a planet existed in our solar system, its gravity would scatter all the other inner planets into deep space, so this system is not likely to harbor life.

The host star is part of a triple star system. The primary star, 16 Cygni A, is slightly larger and hotter than the Sun, while the third member, 16 Cygni C, is a red dwarf much smaller and cooler than the Sun. A and B orbit each other in long, cigar-shaped orbits that take at least 125,000 years to complete. The pair never come closer than about 100 AU, more than twice Pluto's distance from the Sun. The diminutive third member orbits the main pair at a distance of at least 100,000 AU.

"Theorists are having a lot of fun trying to explain this planet," says Cochran. The planet might have formed in a circular orbit around 16 Cygni B, but then had its eccentricity gradually "pumped up" by gravitational perturbations by 16 Cygni A. Another possibility is that gravitational interactions between the three stars early in the system's history could have given the planet its elliptical orbit. Alternatively, a recent model proposed by University of California at Santa Cruz theorists Douglas Lin and Shigeru Ida suggests that colliding Jupiter-mass planets could form supermassive planets in highly eccentric orbits, such as the planets orbiting 70 Virginis and HD 114762.

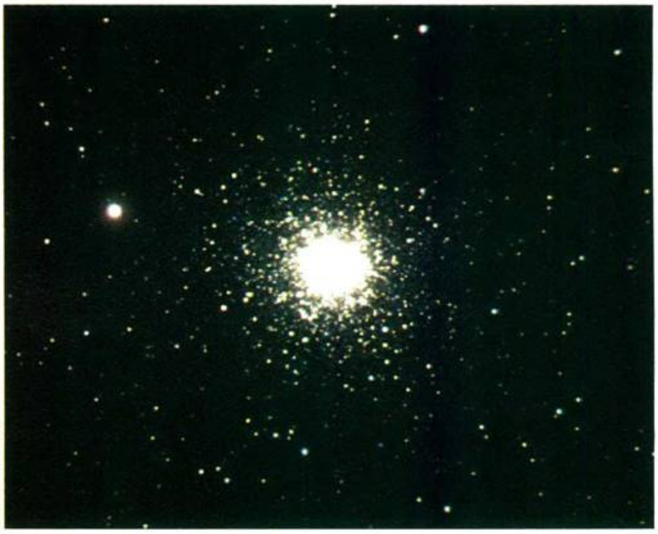
Cochran and his University of Texas colleague Artie Hatzes independently discovered the planet with California-based planet hunters Geoff Marcy and Paul Butler.

Older Stars Not So Old?

How can the universe be younger than its oldest stars? Cosmologists who determine the age of the universe by measuring how fast it is expanding come up with an age of 8 to 12 billion years. But astronomers who model the evolution of stars generally come up with ages of 15 to 17 billion years for the oldest stars. Somebody's got to be wrong!

According to a new study led by Alex Rodgers of the Australian National University in Canberra, those who model stellar evolution need to lower their age estimates by as much as 5 billion years. Rodgers' team studied a class of variable stars known as RR Lyraes in the Large Magellanic Cloud, the Milky Way's largest satellite galaxy. By observing how the RR Lyraes pulsated, Rodgers' team could calculate their intrinsic luminosity, which in turn allowed them to measure the precise distance to the Large Magellanic Cloud. Their distance matches previous measurements based on other methods, assuring Rodgers and his colleagues that their RR Lyrae method can be used to achieve accurate distances to globular clusters — the homes of the most ancient stars in the universe.

Using the RR Lyrae method, the team found that Milky Way globular clusters are farther away than had been previously thought, meaning



James R. Foster

According to a new study, the oldest stars in globular cluster M15 are 12 billion years old, several billion years younger than previously estimated.

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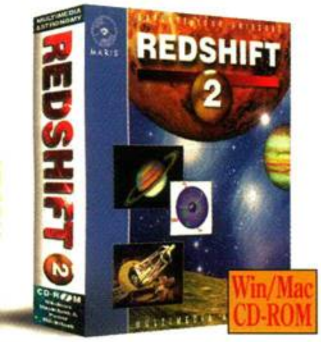

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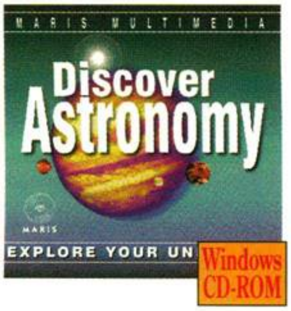

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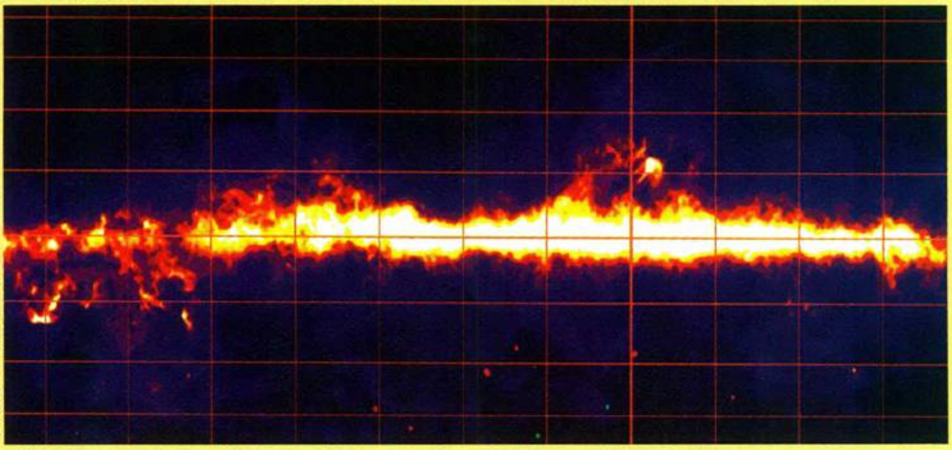


Henry Freudenreich (GSFC)

Astronomers have long believed that our Galaxy is shaped like a disk, but exactly how big is it, and where does the Sun fit in? Most mapping efforts have focused on blue giant stars, which are bright enough to be seen from great distances at visible wavelengths. But blue giants are rare and very young, and may not represent the true structure of the galactic disk. A new study by Henry Freudenreich of NASA's Goddard Space Flight Center instead uses maps made by a near-infrared instrument aboard the COBE satellite. Blue giants are much fainter in the near-infrared, but the older and more common red giants, which are representative of the galactic disk, can be seen from great distances. There is less obscuration by interstellar dust at these wavelengths than in the visible, and where the dust is exceptionally thick it can be avoided on the basis of its characteristic near-infrared color. Among Freudenreich's findings: the Sun is located 50 light-years above the mid-plane of the disk and 70% of the way to its outer edge; and the disk itself is warped — bent slightly upward on one side and downward on the other.

astronomers have been underestimating the intrinsic luminosity of globular cluster stars. This in turn means that stars are ending their hydrogen-burning life cycle sooner, implying globular cluster stars — thought to be the oldest in the universe — are several billion years younger than had been previously estimated. This result remains controversial, but if it is confirmed, it will help solve one of the most perplexing puzzles in astronomy.

Asteroids or Comets?

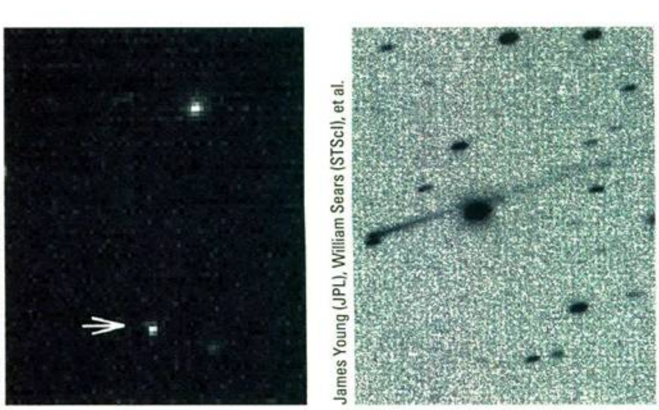
Usually it's pretty easy to tell an asteroid from a comet. Comets have tails, asteroids don't. Comets generally have highly elliptical orbits and take a long time to go around the Sun, asteroids usually have short-period, near-circular orbits. But two recently discovered objects have clouded this picture.

The first body, 1996 PW, looks like an asteroid because it doesn't have a tail. But it has a comet-like 7,000-year, highly elliptical orbit that takes it from the asteroid belt to a distance 20 times farther from the Sun than Neptune.

Several astronomers have proposed that 1996 PW is a dormant comet, a comet whose repeated passages near the Sun cooked its surface ices, leaving behind only dust and dirt. But Alan Harris of JPL argues that before the object could be baked into submission, gravitational encounters with the planets would either settle the comet into a more circular orbit or would eject the comet from the solar system. He thinks 1996 PW originally formed in the asteroid belt, but was kicked out to the Oort Cloud billions of years ago. Recently it was kicked back into the inner solar system.

The other object, 1996 N_2, boasts a comet-like tail, but it orbits in a near-circular, 5.6-year orbit in the main asteroid belt between Mars and Jupiter. Even more bizarre, 1996 N_2's tail doesn't point away from the Sun, like most comet tails do, but instead nearly traces the object's orbital motion.

Because 1996 N_2's orbit is stable, it almost certainly formed in the asteroid belt, meaning it is an asteroid. Because a 1979 image of 1996 N_2 showed no tail, Harris and many other astronomers think a small chunk of rock collided with the object, knocking off debris that forms the tail. "What I find curious is that the tail appears continuous, not broken up into blobs like Shoemaker-Levy 9," says Harris. "I would have expected some blobs to stand out along the string. Ain't nature wonderful? And we thought we'd seen it all with S-L 9." □



Eleanor Helin, et al. (NASA/JPL)

James Young (JPL), William Sears (STScI), et al.

Asteroids or comets? The 5- to 10-km-wide mystery object 1996 PW (left) looks like an asteroid but orbits the Sun like a comet; 3- to 5-km-wide 1996 N_2 (right) sports a comet-like tail but orbits within the main asteroid belt.

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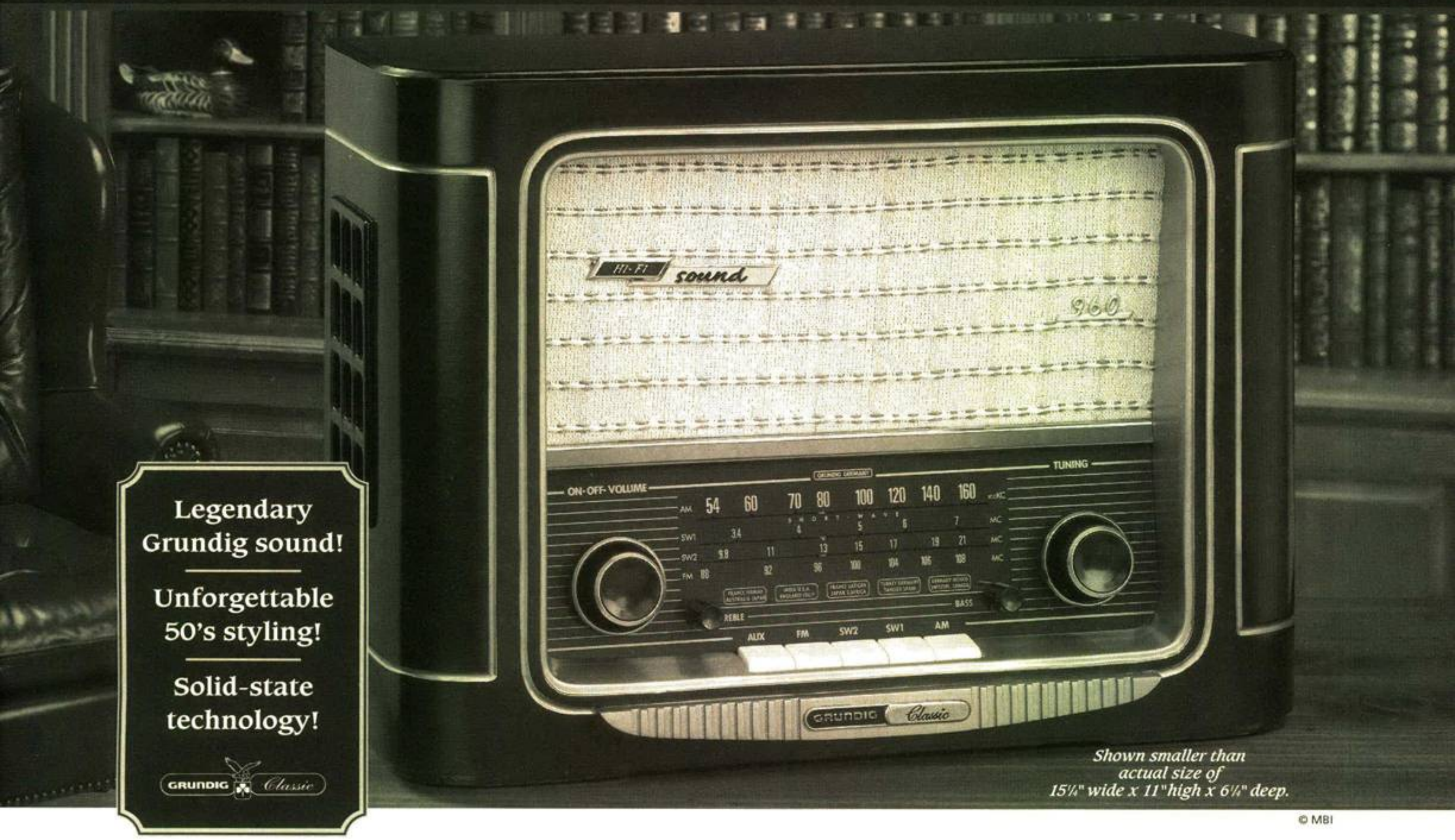

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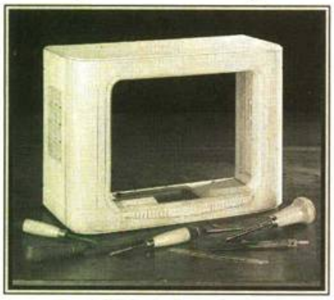

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AMATEUR NEWS

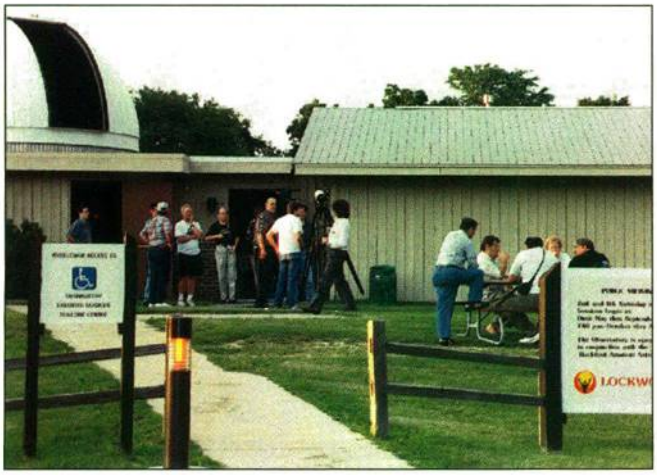
ALCON Lands in Rockford

"Astronomy Around the Clock" was the theme of AstroCon '96, the national convention of the Astronomical League, a federation of more than 200 amateur astronomical societies and clubs from around the United States representing some 12,000 amateur astronomers. The gathering was cosponsored by the Association of Lunar and Planetary Observers (ALPO) and hosted by the Rockford Amateur Astronomers (RAA) at Rockford College in Rockford, Illinois, from July 24 to 27. More than 300 amateur astronomers from all over North America took in tours, papers, workshops, observing sessions, and lectures by professional astronomers.

Richard Kron of Yerkes Observatory spoke about a digital sky survey that will catalog some of the most distant objects in the universe. James B. Kaler of the University of Illinois explained how gases expelled by some planetary nebulae could combine with heavy metals given off by supernovae to produce new stars surrounded by planets. Banquet speaker John R. Percy of the University of Toronto encouraged clubs to foster astronomy education by helping to develop school science curricula. Percy received the 1996 Astronomical League Award for his work in astronomy education.

Other activities complemented the speaker roster. Experienced variable star observers conducted a workshop one afternoon and ALPO members presented papers and training sessions on planetary viewing. Other amateur papers covered CCD imaging, making astrovideos, cosmology, robotic observatories, radio astronomy, and lunar occultations.

A center of attention was the RAA observatory


ASTRONOMY: Dan Koehler

Astronomy enthusiasts wait for darkness at the Rockford Amateur Astronomers' observatory during ALCON '96. The four-day annual meeting drew several hundred people from all over North America.

EVENT HORIZON

Extrasolar Planet Distances Refined

The European Space Agency has just released the most accurate and up-to-date distance measurements to 118,000 stars. The measurements come from ESA's satellite Hipparcos, which measured stellar distances from 1989 to 1993. Of particular interest are three solar-type stars orbited by substellar companions. The distances are: 51 Pegasi, 50 light-years; 70 Virginis, 59 light-years; and 47 Ursae Majoris, 46 light-years.

Arizonans Get New Planetarium

April 1997 will see the dedication of a new science center for Phoenix, Arizona. The 40,000 square-foot building will house a wide-screen theater, numerous hands-on science exhibits, and a 200-seat Digistar planetarium under a 60-foot dome. The planetarium will employ advanced computer graphics to simulate astronomical objects such as planets, stars, and constellations and produce a number of special effects, including three-dimensional space flight.

Assadi Associates

The new Arizona Science Center will open in early 1997.

Faraway Bursts

A new catalog of gamma-ray bursts from the Compton Gamma Ray Observatory adds to the growing weight of evidence that these mysterious flashes take place at enormous distances. The new catalog increases the total number of bursts to 1,122 and includes all the bursts seen from April 19, 1991, to September 19, 1994. The burst distribution continues to be uniform across the entire sky, with no apparent clustering toward the plane of the Milky Way Galaxy — indicating that most gamma-ray bursts occur at distances of hundreds of millions or billions of light-years.

Darn Those Rascally Neutrinos

Japan's Kamiokande neutrino detector, which shut down in 1995 after nearly a decade of successful operation, has failed to register any hint of the 11-year solar cycle. Nuclear reactions in the Sun's core produce billions of neutrinos every second. But these subatomic particles are so elusive that all but a tiny fraction pass through Earth without interacting with matter. Scientists were hoping Kamiokande would see some hint of variations matching the 11-year solar cycle, but none were found. A new and improved neutrino detector, Super Kamiokande, went on-line in April 1996. In other solar neutrino news, a Stanford University team reports that solar neutrinos peak every 21.3 days. At present, there is no explanation for this.

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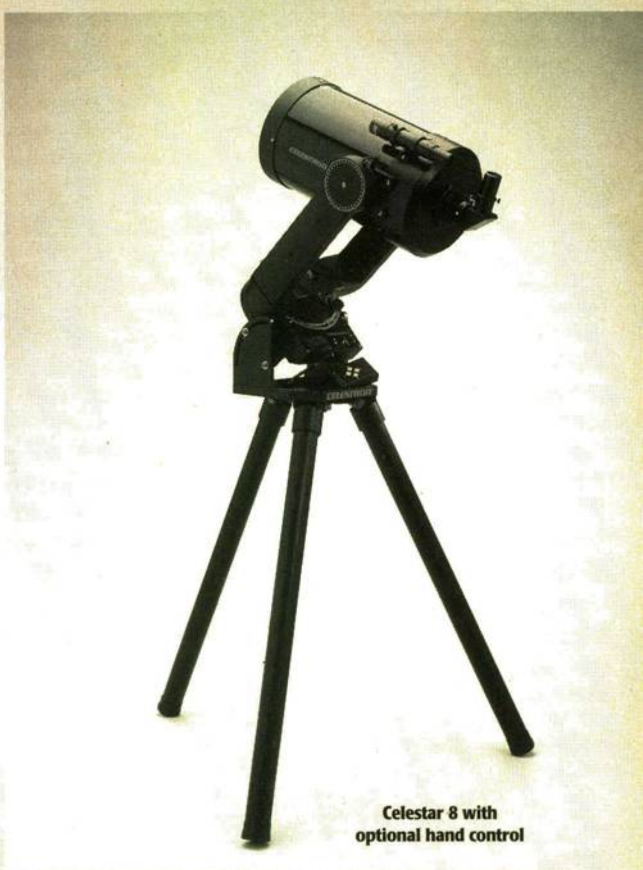

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Celestron International • 2835 Columbia Street, Torrance, CA 90503 • (310) 328-9560 • FAX (310) 212-5835 that houses a 12-inch reflector, a 10-inch refractor, and a new 10-inch solar telescope. Walter Piorkowski, the solar telescope's builder, directed a two-hour-long workshop on solar observing.

Another convention highlight was a presentation of the League's 1996 National Outstanding Young Astronomer Award to Mani Mahjouri of Columbia, Maryland. The annual award goes to a high school student with the best astronomy-related science project in the United States. Mahjouri was given an engraved plaque and a 16-inch telescope donated by Meade Instruments Corporation for his study of charged particle motion in Jupiter's magnetosphere.

Next year's League convention, the 50th anniversary of the organization's founding, will take place at Copper Mountain, Colorado, on July 1 through 6.

Hams Get a Boost from Perseids

Astronomers aren't the only ones who anxiously await the Perseid meteor shower each year. For amateur radio operators like Rich Westerberg of Eden Prairie, Minnesota, the meteor shower is a highlight of the year.

During the Perseids, amateur radio operators bounce VHF (very high frequency) signals off the meteor trails. According to Emil Pocock (call sign W3EP), editor of "The World Above 50 MHz" column for the American Radio Relay League's *QST* magazine, the meteor trails act like mirrors, reflecting VHF signals hundreds or even thousands of miles. Normally, VHF signals are used for local communication.

"The skip that results from signals bouncing off the meteor trails allows you to send and receive VHF signals much farther than normal," Pocock says. "Some amateur operators have made contacts as distant as 1,500 miles."

Westerberg, whose Amateur Radio call sign is N0HJZ, says the 1996 meteor shower was one of the best ever.

"The Perseids were good, really good," Westerberg says. "You could tell the direction the meteors were traveling by the location of the stations. In one instance, I heard a station from New Jersey and two seconds later, a ham from North Carolina faded in. I assumed their signals bounced off the trails of the same meteor moving to the southwest."

Westerberg has used this unusual form of radio propagation to swap call signs with amateur radio operators in 30 states and Canada. Although the Perseid meteor shower is one of the most intense, Westerberg says the upcoming Leonid and Geminid showers should provide exceptional meteor skip opportunities.

For more information, contact Pocock at 860-642-4327, or email him at w3ep@arrl.org. Westerberg can be reached via email at N0HJZ@aol.com. To become involved in ham radio, contact the American Radio Relay League, 225 Main Street, Newington, CT 06111 or call 1-800-32-NEW-HAM. — *Mike Nikolich*

Karen Kerans

Telescopes of all shapes and sizes line a low ridge at the 1996 Nebraska Star Party, held south of Valentine. The August 10-17 event was highlighted by an impressive display of Perseid meteors.

On the Plains of Nebraska

I can't stop telling people about the Nebraska Star Party. Dark skies stretched unobstructed in all directions, and the telescopes ranged in size from 30-inch Dobs to 4-inch Astroscans. Granted, this was my first big star party, but I've never seen so many scopes in one place.

I went to Nebraska primarily to see the Perseids from a dark site. Everything else was astronomical gravy. My goal the first night was to look through as many scopes as possible. I got spectacular views of Jupiter and its moons, the Swan Nebula (I could clearly see the swan's neck and shoulders), numerous globular clusters, and the North America Nebula.

A special thrill was my first view of Uranus. When I excitedly reported this to my friends, they showed me Neptune. Some guys from Wisconsin shared a terrific view of Hale-Bopp and then showed me where to find it with the naked eye. I then shared the location with a young man and his father, who were enjoying their adventure on another ridge.

Although I saw plenty of expert observers, you didn't have to be one to fit in. I even spent time with one fellow who was busy learning the constellations.

I spent my second, and last, night watching meteors. The Perseid shower has always been one of my favorite events. There's no equipment or expertise required, and it impresses everyone who sees it. I was glad to see that the thrill wasn't lost on the party's seasoned observers. I often heard: "Look — that one split" and "Did you see the color in that one?" I loved it.

The 1997 Nebraska Star Party is scheduled for August 2-9. Although it won't coincide with the peak of the Perseids, I plan to be there. I hope to see you. — *Karen Kerans* ☐

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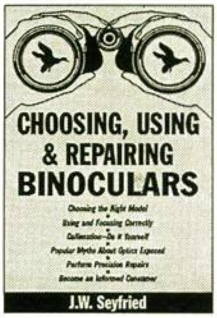
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What Makes Galaxies Change?

Conflicting evidence suggests galaxies are driven either by their own character or the environment that surrounds them.

by Marcia Bartusiak

About two-thirds of all large, regular galaxies in the universe are stately spirals, like this one — M100 in Coma Berenices.

The Big Bang gets all the press, but a much larger story remains to be told. How did we get to here (the Milky Way) from there (a vast primordial explosion)? How did those vast collections of stars we call galaxies evolve into the universe we currently behold? Why did some galaxies become spiraling disks of gas, while others turned into bulbous ellipticals? And how did the populations of each galactic type change over the eons?

Edwin Hubble first pondered these questions more than 60 years ago, soon after he confirmed that the Milky Way was but one of billions of other galaxies roaming the vast gulfs of space. A few hardy souls, the most patient and persistent observers in extragalactic astronomy, eventually joined the pursuit, including Augustus Oemler, who has been wrestling with these mysteries for more than two decades. "Very few things in astronomy, from discovery to understanding, happen quickly," notes Oemler, who is director of the Observatories of the Carnegie Institution in Pasadena, California.

Answers have remained elusive for good reason: The deeper astronomers peer into extragalactic space (and consequently back into time), the more they must strain their telescopic "eyes." Even with the largest telescopes, galaxies that reside more than a couple billion light-years away appear dim, small, and indistinct. A fundamental quest in astronomy, determining how galaxies originated and evolved, seemed an impossible endeavor.

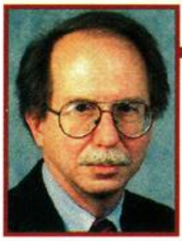
Elliptical galaxies like M87 in Virgo comprise about one quarter of the cosmos' large galaxies. Their dominant population of old stars gives them their characteristic reddish color.

All galaxy photos on this spread: Anglo-Australian Telescope Board

About 10 percent of large galaxies are neither spirals nor ellipticals, but are known as S0 galaxies, or lenticular galaxies, which have characteristics of both types. This lenticular is NGC 5102.

But now there is a palpable excitement in the air. Oemler and a loose confederation — five other astronomers hailing from England, the Netherlands, Australia, and California — have joined forces in recent years to interpret a blizzard of data from the Hubble Space Telescope. Based on the group's proposal, the space telescope had intermittently focused on 10 rich clusters of galaxies scattered about the celestial hemisphere, each cluster situated from 4 to 5 billion light-years away, nearly halfway back to the moment of creation. Distant galaxies that were mere smudges could at last be viewed with impressive clarity. And what the Hubble search revealed was a universe far different from the one observed today.

Five billion years ago, an age when our solar system was just starting to form, there were simply more spiral galaxies around. Oemler and his fellow cosmic evolutionists want to know how the universe got from that vibrant state several billion years ago to the more settled, tidy version we now see around us. More than that, they'd like to find out what happened to those extra galaxies.



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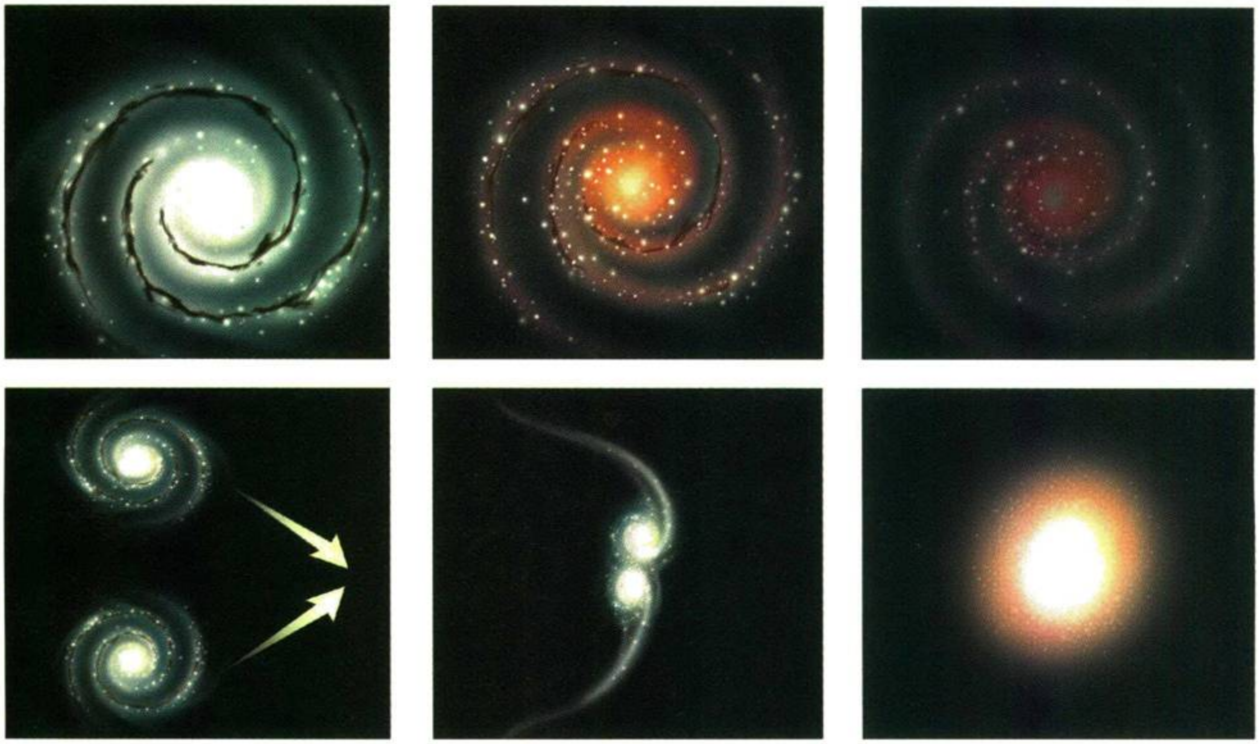
"Very few things in astronomy, from discovery to understanding, happen quickly."
— Augustus Oemler


ASTRONOMY: Elisabeth Rowan

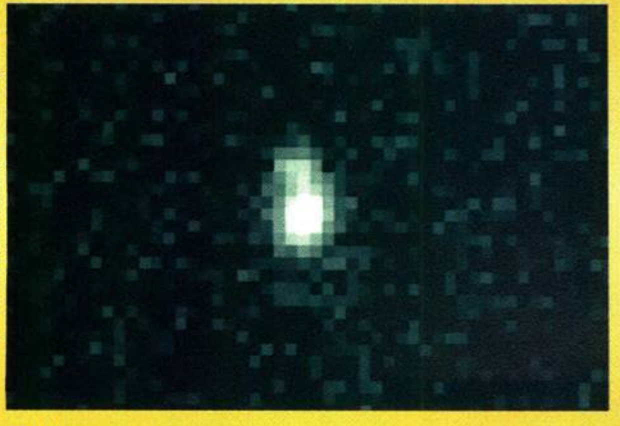
Is galaxy evolution due to nature or nurture? Do galaxies change because of internal processes, or do they change due to outside influences? It's probably a little of both. On the top, we see an example of nature. A spiral galaxy gradually converts its gas into stars. Over time, the stars fade and die. Today, the galaxy is a dim shadow of its former self. On the bottom, we see the forces of nurture at work. Two spiral galaxies in a cluster collide, forming long tidal tails. Eventually the pair merge to form an elliptical galaxy.

Formerly competitors, these extragalactic astronomers teamed up to use the Hubble Space Telescope more efficiently as an international resource. Richard Ellis of Cambridge University, Alan Dressler of the Observatories of the Carnegie Institution, Warrick Couch of the University of New South Wales in Australia, and Harvey Butcher of the Netherlands Foundation for Research in Astronomy, as well as Oemler, have been independently classifying galaxies in the Hubble images. As a cross-check for accuracy, they separately assessed each galaxy's size, type, and magnitude — many thousands of objects in all. "Hubble finally allows us to sort these far galaxies into categories," explains Ellis. "We can now tell the spirals from the ellipticals. Previously, from the ground, we could only say that something was red or blue, big or small."

Another group member, Ian Smail of the University of Durham in England, is attempting to measure the total mass of each distant cluster. Rich clusters of galaxies, with their huge gravitational fields, can act as lenses. Like a stream of water that comes upon a rock

Elliptical Galaxies Through Time

A. Dressler, M. Dickinson, D. Macchetto, M. Giavalisco, and NASA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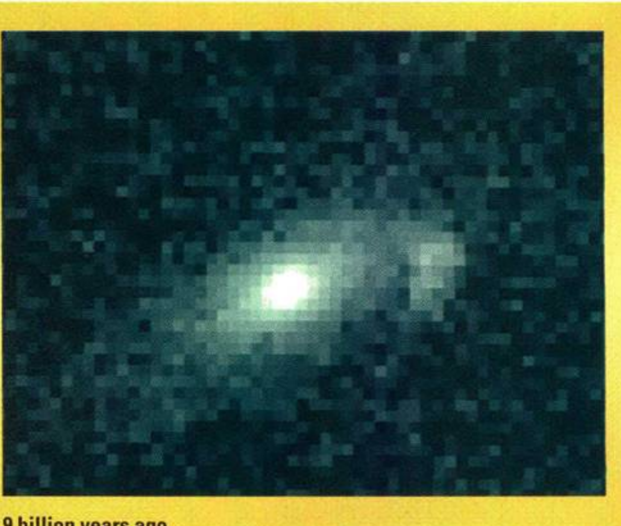
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and gets diverted to either side of the stone, the light from a distant galaxy caught behind a cluster can be split up. This gravitational lensing — an effect rooted in Einstein's general theory of relativity — also magnifies the light. Smail observes how massive clusters bend the beams of light passing by from more distant galaxies. That will give him a handle on the clusters' assorted environments.

Each of these researchers has been pursuing the same goal; they want to know whether a galaxy is shaped primarily by "nature" — the celestial "genes" it inherits at birth, such as its size, mass, and rotation rate — or by "nurture" — the galaxy's later encounters with its environment, such as neighboring galaxies or intergalactic gas.

Such questions were not being discussed when Oemler first started out in astronomy. "If you asked the average astronomer in the 1950s or 1960s, 'Do galaxies change?' they would have said no," recalls Oemler. They were being swayed by the theories of the day; then-current models of our galaxy's construction suggested that it collapsed rather quickly out of a spherical blob of gas. Most astronomers assumed this happened for all types of galaxies, each system forming during a brief, galaxy-forming epoch shortly after the Big Bang. These galaxies, as the story went, then coasted along in the ensuing years, remaining serene and immutable.

The largest number, about two-thirds, emerged as spiral galaxies, with bright round or barred cores surrounded by lush pinwheels of dust and gas. Others became ellipticals: egg-shaped conglomerations that are populated with old, red stars and largely exhausted of the gaseous resources needed to make stars. About 10 percent ended up in a state known as S0s, or lenticular galaxies, which have characteristics of both spirals and ellipticals. Lenticulars consist of a sizable bulge enwreathed with completely smooth disks of stars devoid of spiral arms.

Yet clues were scattered throughout the heavens that a galaxy's life is not that simple — that galaxies have not drifted through space in tranquillity since the Big Bang. Even Hubble noticed that gas-depleted ellipticals and lenticulars were predominant in the universe's "urban areas," the centers of rich, packed clusters, where hundreds to thousands of individual galaxies huddle together. Spirals are more commonly found in the "field," the more sparsely populated or rural regions of space.

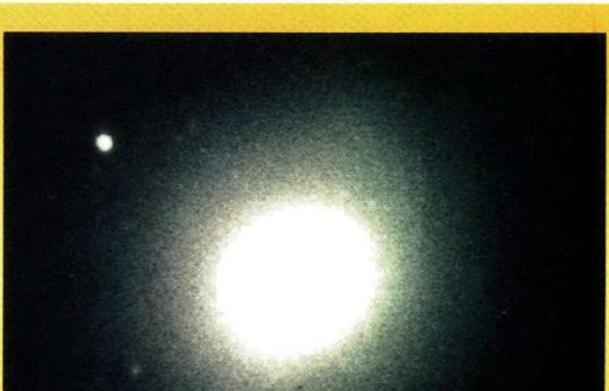
Did this segregation happen from the start, based on the initial conditions of galaxy formation? Perhaps ellipticals and lenticulars were selectively born where the primordial gas was densest. Dressler long championed that idea. Or possibly those ellipticals were created later on, when an initial population of gas-rich spirals fell into a cluster and merged. Oemler favored that scenario. "I used to insist that everything was due to evolution in clusters," says Oemler. "Alan and I argued these points in journal papers for more than a decade." Today, they are coming to believe it's probably a little of both.

Alan Dressler

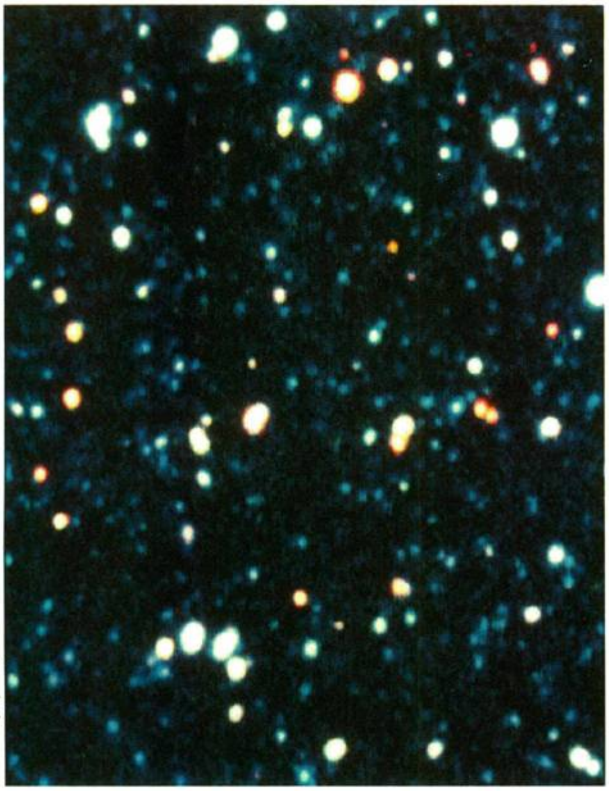
"Galaxies just don't look like that today, I hardly know how to classify them."
— Alan Dressler

The roots of this debate can be traced back to 1978, the year that astronomers obtained the first direct evidence that galaxies were indeed evolving over time. Using the 84-inch telescope on Kitt Peak in southern Arizona, Oemler and his longtime collaborator Harvey Butcher analyzed the colors emanating from two galaxy clusters situated some 5 billion light-years away (hence 5 billion years back in time). And what they saw was somewhat unexpected: Both clusters' galaxies were radiating more blue light than the clusters seen near us today, which tend to be

5 billion years ago

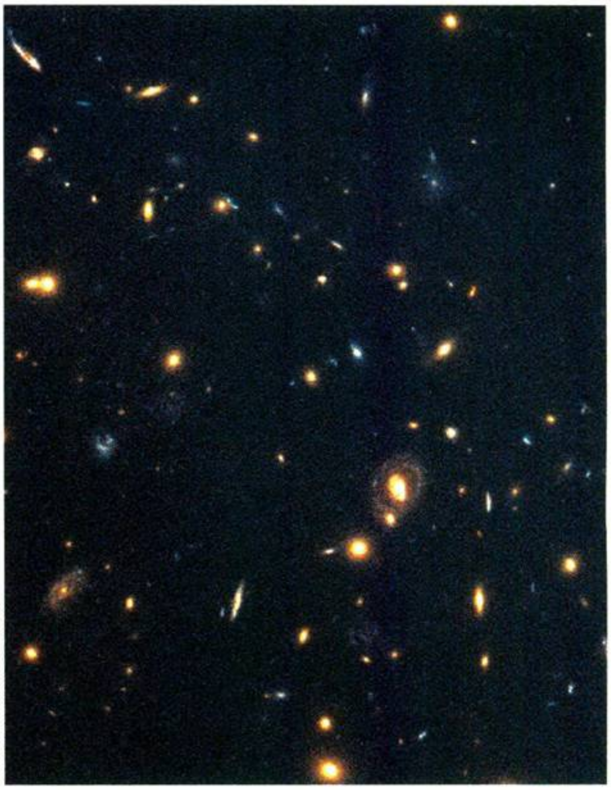


A few million years ago



J. Anthony Tyson (AT&T Bell Labs)

Ground-based telescopes show distant blue galaxies as smudges of light devoid of shape. To understand how galaxies change with time, astronomers needed the Hubble Space Telescope.



Ian Smail (Univ. of Durham)

Hubble reveals distant galaxies in all their glory. By comparing the shapes of distant galaxies to their nearby counterparts, astronomers can piece together the story of galactic evolution.

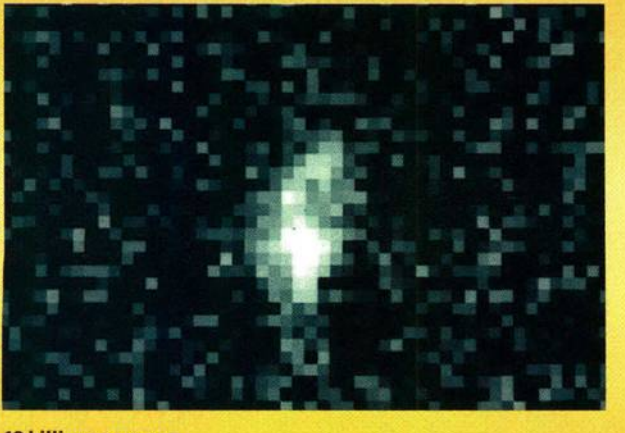
red. This bluish characteristic of populations of galaxies in distant clusters was soon dubbed the Butcher-Oemler effect.

Even as Butcher and Oemler were gathering their data, Yale theorist Beatrice Tinsley was modeling how entire populations of stars age within a galaxy. She concluded that galaxies can undergo substantial internal evolution through time, more than previously assumed. A young galaxy can start out bright and blue, when the gaseous resources needed to form stars are at their peak, and then gently redden with age and fade away over the eons as the stars age and die.

But others wondered whether the Butcher-Oemler effect was a sign that great upheavals were taking place in that far-off time: Could galaxies be dimmed, brightened, or altered owing to influences from outside the galaxy? Perhaps the galaxies were colliding, merging, and consequently "starbursting," vigorously forming stars at hyper-accelerated rates. Theory was on their side. At MIT in the 1970s, mathematician Alar Toomre was beginning to conduct his groundbreaking computer simulations that showed how two spiral

Spiral Galaxies Through Time

A. Dressler, M. Dickinson, D. Macchetto, M. Giavalisco, and NASA



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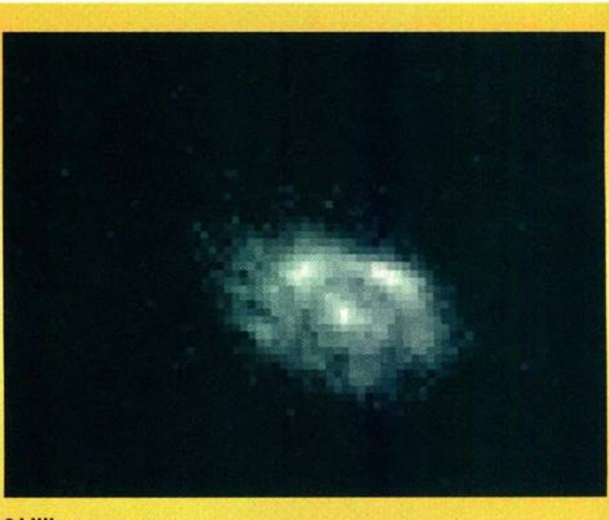


9 billion years ago

Harvey Butcher

Harvey Butcher and his colleagues have been independently classifying galaxies in the Hubble images.

galaxies can merge to form an elliptical galaxy.

Something was obviously happening in these clusters. Following up on Butcher and Oemler's finding, first Dressler in California and later Couch in Australia obtained spectra of the distant galaxies and saw evidence of heightened star formation. "A spectrum can tell you a lot," explains Couch. "We found emission lines, which means that star formation is definitely going on. But we also found lots of hydrogen absorption lines from A-type stars, which hang around for only a billion years or so. So, we were seeing galaxies within a billion years of a starburst."

Obtaining additional information over the next 15 years, though, was a struggle. Astronomers switched from photographic plates to CCDs — digital imaging — which offered a better look at the clusters. But not good enough. The blue objects in Oemler and Butcher's far clusters were still indistinguishable, no more than faint blobs.

It was the amazing resolution of the Hubble Space Telescope that provided a quantum leap in this endeavor. "It really hits you when you look at these Hubble images, just how beautiful the galaxies are," says Couch. "Exquisite detail." Astronomers could at last see directly what was only guessed at or suspected. The bluer objects in the far clusters were definitely spiral galaxies and, more important, they existed in numbers greater than in clusters today. "That's a big step forward," says Oemler. "It could have been that the blue things we saw had nothing to do with normal galaxies. We always suspected they were spirals, but we couldn't prove that until we had the Hubble Space Telescope."

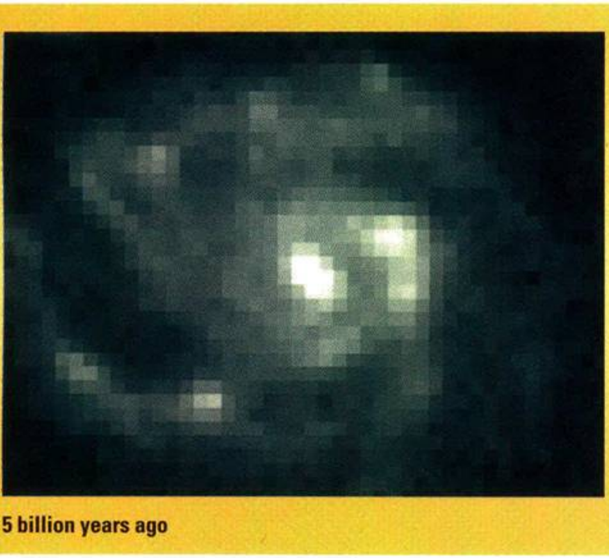
The appearance of these distant galaxies, though, is making astronomers redefine the term "normal." They are spirals, but very strange-looking spirals indeed. Oemler brings up the image on a computer workstation of one particular cluster under study. Scanning over the picture, he points to many galaxies in the cluster that are ragged and asymmetric. "You also see all these rings," he notes. "Galaxies just don't look like that today." Dressler adds, "It's full of twisted, funny spiral galaxies. I hardly know how to classify them." One of the group's tasks is gauging the degree of "blobbiness" in each galaxy — in other words, how much the galaxy is distorted compared to a more normal disk galaxy. In this way, they hope to glean clues on the origins of those distortions.

Warrick Couch

"It really hits you when you look at the Hubble images, just how beautiful the galaxies are." — Warrick Couch

At first, the group was tempted to conclude that mergers explained it all — that these unusual spirals, types no longer seen today, simply paired up to become something else, most likely elliptical galaxies. Interactions are certainly occurring; some of the galaxies are elongated and have tidal bridges between them (see "Galaxies Colliding in the Night," November 1996). But that simple scenario no longer explains all that they are seeing.

For one, there are problems with mergers within a cluster: Galaxy velocities are so fast within a cluster, up to 1,000 kilometers per second, and stars are spaced so far apart, that the stars would merely pass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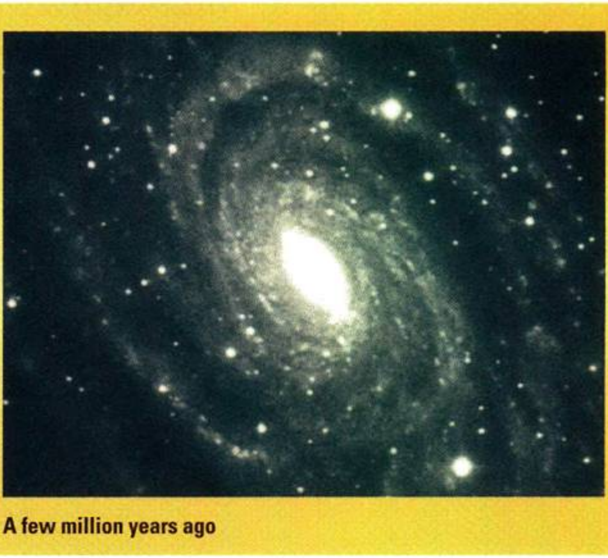

A few million years ago

by one another with hardly a fare-thee-well. Even if the spirals did somehow merge, the newly formed ellipticals would be rich in blue, star-forming light because the colliding clouds of gas and dust would trigger a new round of star formation. But all the big elliptical galaxies in these clusters appear red and long settled. Ellis is checking to see if any of the ellipticals display a smidgen of residual blue light, a sign of prior merging and star formation. "But so far," he says, "the bulk of the luminous ellipticals in these clusters look very old." Their births seemed to have occurred much further in the past. This seems to bear out Dressler's long-cherished belief that ellipticals are a product of "nature" more than "nurture."

But the spirals may be another matter entirely. The group is now considering whether the bizarre-looking spirals were, instead, altered in some way. A spiral's gas and dust could have been be stripped away as it zoomed through the relatively dense gases hovering throughout the cluster. Maybe in that way, suggests Couch, the spirals turned into lenticulars. "The fraction of lenticulars in nearby clusters is very high," he notes, "but it is low in these younger clusters."

Or the distant galaxies could have been "harassed" (as astronomers like to call it these days), whittled down by tidal forces as they gravitationally encountered other passing galaxies. This encounter would compress their gases, and new stars would flare up, speedily depleting the galaxy's gaseous resources. Today, too dim to be photographed, these spiral galaxies seem to have vanished from the universe. Astronomers have recently begun finding hordes of dim galaxies that contain very few stars (see "Ghost Galaxies of the Cosmos," June 1996). Maybe these are the ghostly remains of these distant blue spirals that once burned brightly many eons ago. But that's only speculation at this point. "I'm not yet convinced that we've found enough dim galaxies nearby to explain what's going on," says Ellis.

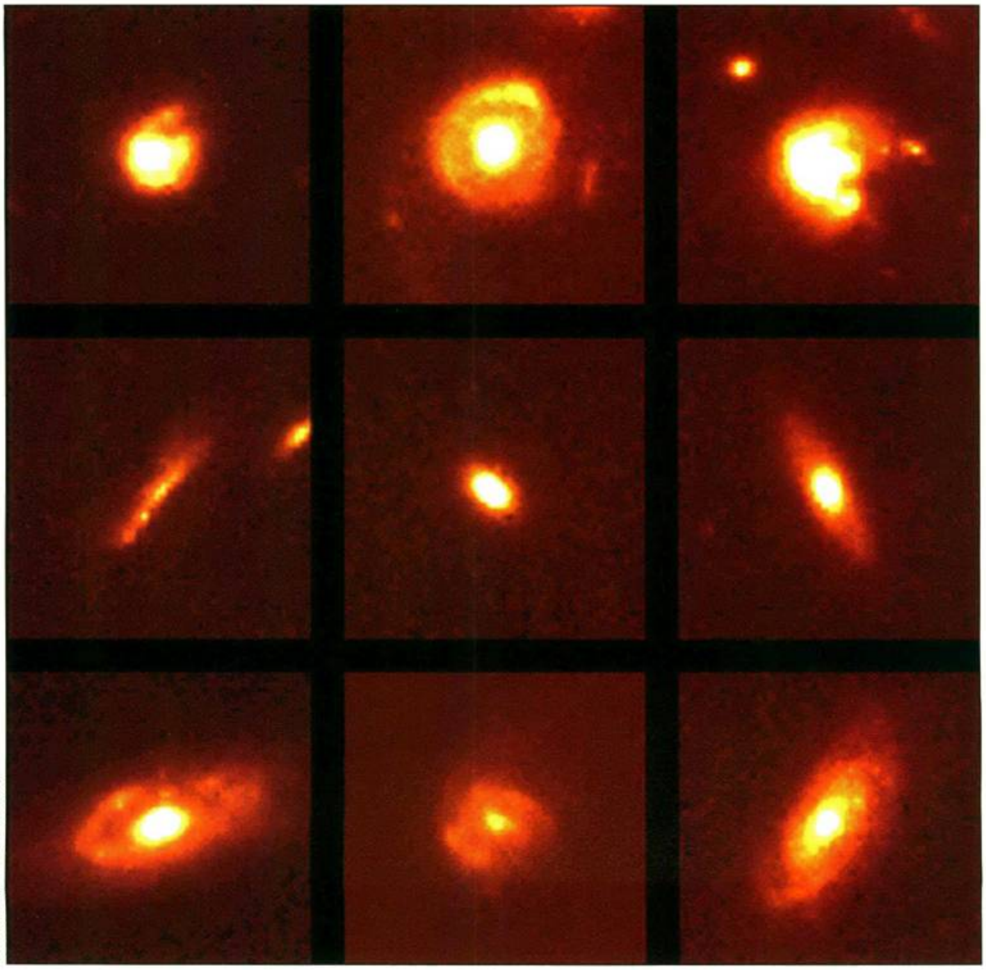
Richard Ellis

"Hubble finally allows us to sort these far galaxies into categories."
— Richard Ellis

"We need to find the smoking gun," adds Oemler.

What would help would be to compare what's happening in the urban areas, that is the central area of the clusters, with what's happening in the field. Fortunately, Hubble is also carrying out the Medium Deep Survey, a set of long-term exposures of distant galaxies in the field. And the view there is just as bizarre as in the clusters. Astronomers are seeing many faint, blue, irregular galaxies in deep space, far more than seen today (see "Our Strange, Scrappy Ancestors," December 1995). Either they've stopped forming stars and so have now faded away, or they've come together to form more normal-looking galaxies. Whatever the reason, the change provides further evidence that the universe has indeed evolved over time.

If galaxies both in the field and in the clusters are following the same course, then it would point to nature having the upper hand. Where a galaxy is located doesn't matter; it's just following


Ian Smail (Univ. of Durham)

Nine spiral galaxies as they existed halfway back to the moment of creation. Many spirals in that distant epoch had distorted shapes. These spirals have no counterparts in the modern-day universe.

Robert Williams and the Hubble Deep Field Team/STScI and NASA

Galaxies through time: Last year the Hubble Space Telescope took a 10-day exposure of a tiny patch of sky, revealing galaxies in the local, intermediate, and distant universe.

its own internal life cycle. "In other words, those distant spiral galaxies could be ragged and scruffy simply because that's what galaxies looked like back then," points out Dressler. But if the evolution of a galaxy differs in those disparate environments — field and urban center — then a strong finger is pointed at nurture doing the job. The change a galaxy makes would depend on its surroundings, its encounters with other galaxies over time.

Ian Smail

Ian Smail observes how massive clusters bend the beams of light passing by from more distant galaxies.

Answers will arrive with additional observations, especially spectral measurements from the ground. Only there are the mirrors big enough (particularly on the new 8- and 10-meter-class telescopes) to capture sufficient light from those distant regions to dissect the light into its spectral components. That will help astronomers determine what is causing the bursts of star formation in those far galaxies. Hubble's relatively small 2.4-meter mirror, while superb for imaging because of its position above the atmosphere, cannot gather enough light to do spectroscopy on particularly dim objects.

"We've got a series of snapshots," says Oemler. But they need the see the entire movie, including scenes closer in as well as farther out. A new wider-field camera on Hubble, scheduled for installation in 1999, will help astronomers view nearby clusters, which extend over a broader swath of sky. But getting deeper images will eventually require new instrumentation because Hubble is not optimized for viewing the primeval universe.

Waves of light from distant space stretch out with the universe's expansion, so going deeper into space means peering at longer and longer wavelengths, beyond the visible spectrum — into the infrared. Dressler recently chaired a committee that recommended the construction of a future 4-meter infrared space telescope, nearly twice the size of Hubble, to view the era of galaxy formation some 10 billion light-years distant or more. "In the current competition for financial resources, we're probably talking about something 15 to 20 years from now," says Dressler. But NASA has jumped on the Dressler committee suggestion, and is now looking at the possibility of building an even larger space telescope with a 6- to 8-meter mirror and launching it as early as one decade from now. "The power of such a telescope to look back to the era of galaxy birth would be awesome," adds Dressler.

In the meantime, Smail is working on a clever technique to discern some information on galaxies farther out. As pointed out earlier, rich galaxy clusters can act as lenses. Smail is testing a method of estimating the distance of those far galaxies by the amount their images are distorted — elongated — by the lensing effect.

But, for now, the group is simply relishing the view from Hubble. "That's the most fun of all," notes Oemler, "just staring at these pictures." Dressler muses: "For as long as all of us have been trying to figure out whether nature or nurture is the key to galaxy evolution, it's hard to believe that Hubble and the giant new telescopes like Keck are finally giving us some answers — it's some of both. It's funny how many things turn out that way." ☐

Marcia Bartusiak is a Massachusetts-based science writer. Her previous article for ASTRONOMY, *"The New Dark Age of Astronomy," appeared in the October 1996 issue.*

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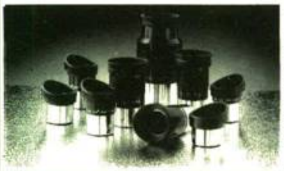

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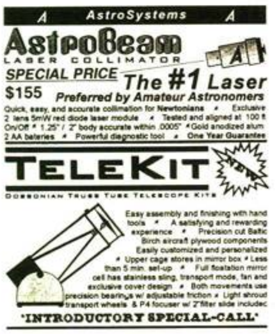

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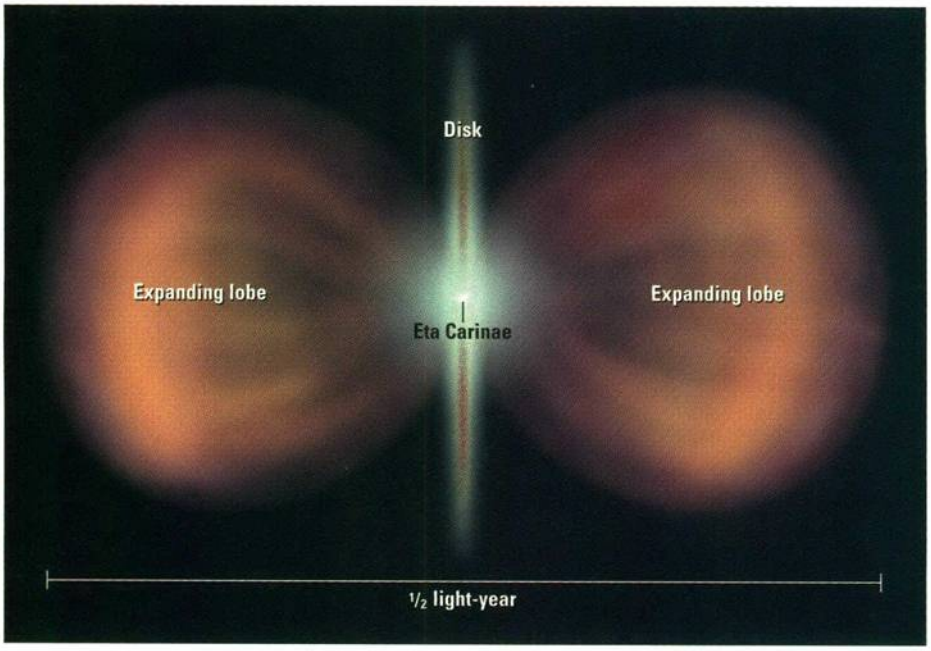
Star on the Brink

In 1837 Eta Carinae blew off more than a Sun's worth of mass. But that was just a prelude for what is to come.

by Robert Naeye



ASTRONOMY: Elisabeth Rowan

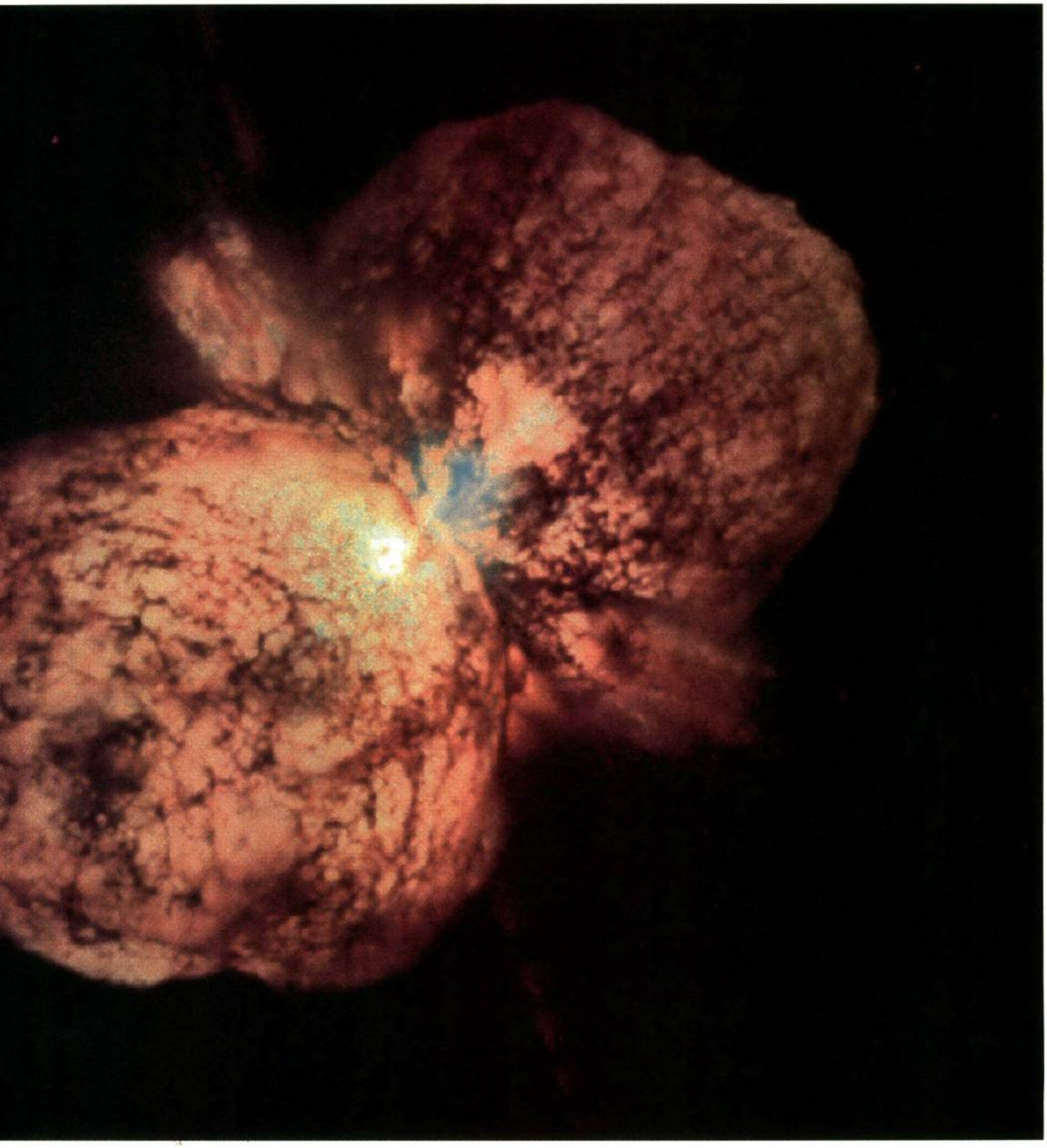
Eight thousand light-years away in the southern constellation Carina lies one of the mightiest stars known to astronomers: Eta Carinae. Weighing in with a mass of at least 100 Suns, Eta Carinae pumps out five million times the energy of our Sun. Earth would be roasted instantly were Eta Carinae to be substituted for the Sun.

As impressive as this sounds, Eta Carinae's life cycle is even more extraordinary. The star is like a gutsy heavyweight champion who keeps getting knocked to the canvas, but who repeatedly picks himself up to resume the fight.

Currently Eta Carinae is barely visible to the naked eye due to its great distance from Earth. But in 1837 the star flared up, and it remained the second brightest star in the night sky, after Sirius, for two decades. Thanks in part to the Hubble Space Telescope and the image-processing wizardry of University of Colorado astronomer Jon Morse, astronomers are finally piecing together the story of what happened.

The Hubble image shows two expanding lobes of gas and dust zooming away from the star in opposite directions at 2.5 million kilometers per hour. When astronomers calculate the motion backward, they determine that the lobes were ejected in the 1837 flareup. In addition, a thin disk of gas and dust is shooting away from the star's equator in the area between the expanding lobes. Eta Carinae apparently suffered a titanic explosion that blew off two or three Suns worth of material. But the feisty star managed to survive. "This was the most cataclysmic non-terminal stellar explosion we know of," says University of Minnesota astronomer Kris Davidson.

Astronomers still don't know exactly what caused the outburst. One possibility is that pressure from light trapped inside the star built up until it suddenly burst through the outer envelope in a cataclysmic



Jon Morse and NASA

This near true-color image from the Hubble Space Telescope shows two lobes of gas expanding like balloons away from Eta Carinae (the bright white spot in the middle). University of Colorado astronomer Jon Morse suppressed the brightness of the star to bring out details in the lobes, which are 100,000 times fainter than Eta Carinae. The dark tendrils in the lobes are dust lanes about the width of the solar system.

eruption, just as steam pressure builds up underground before a geyser erupts. Because most of the star's mass lies below the outer envelope, the star managed to survive the catastrophe.

Davidson thinks this cycle might repeat itself every few thousand years. In 3000 B.C. the Sumerians recorded a bright new star just above the southern horizon. This was probably Eta Carinae, bolstering the notion that the star experiences sporadic eruptions.

Eventually, however, Eta Carinae will suffer the fate of all supermassive stars: Its core will collapse and the entire star will explode as a supernova, providing a grand spectacle for Earthlings. "It will probably go supernova in the next few tens of thousands of years," says Davidson, "but I wouldn't be too amazed if it explodes tomorrow." □

Back to Mars on All Sixes

A six-wheeled, cat-sized rover and its companion lander mark NASA's return to the Red Planet.

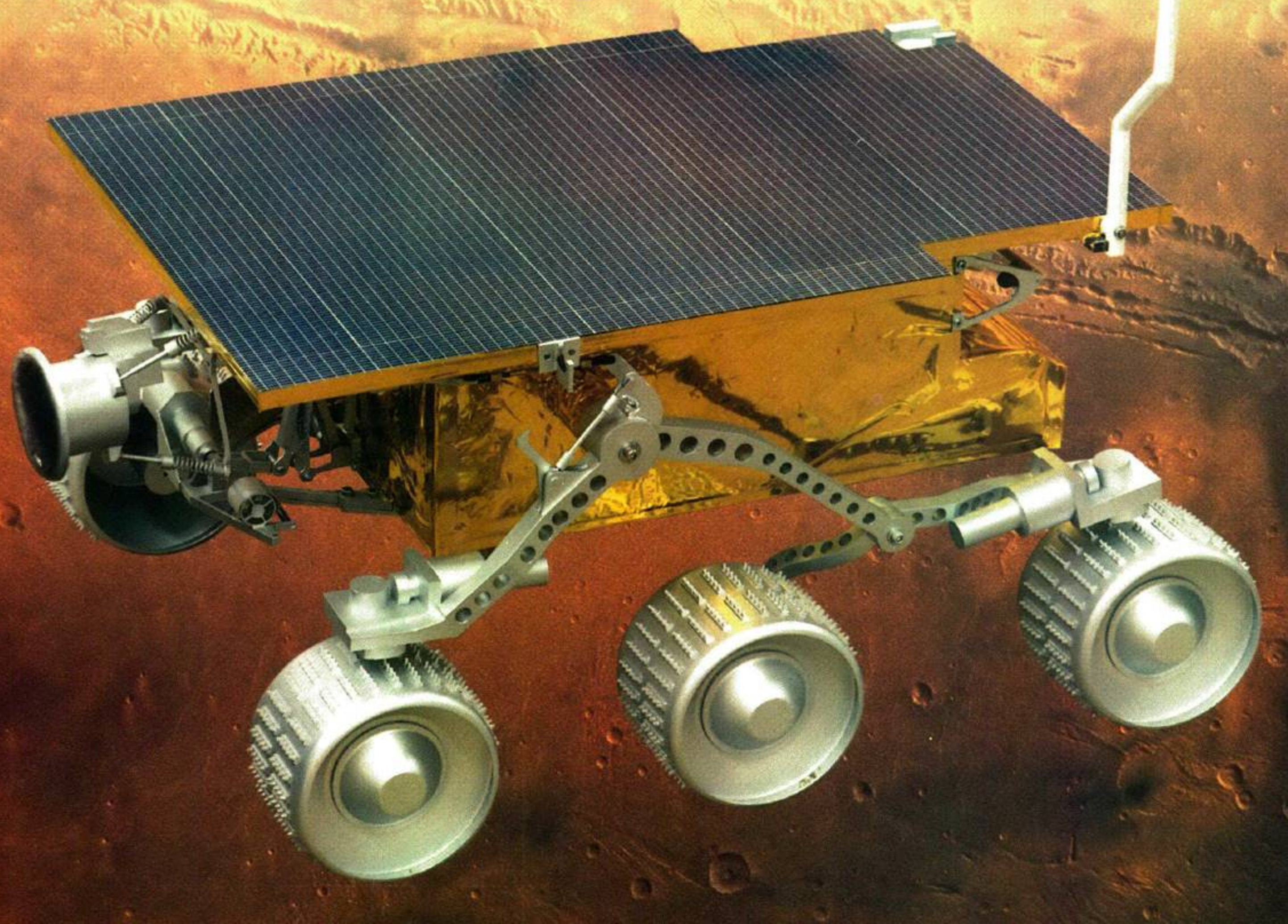
by John Shibley

As you read this, an international armada of spacecraft is closing in on the Red Planet. While the fleet won't directly answer whether Mars harbors life, it will help construct a planetwide geological and atmospheric survey, setting the stage for future missions that seek out Martians, if they exist.

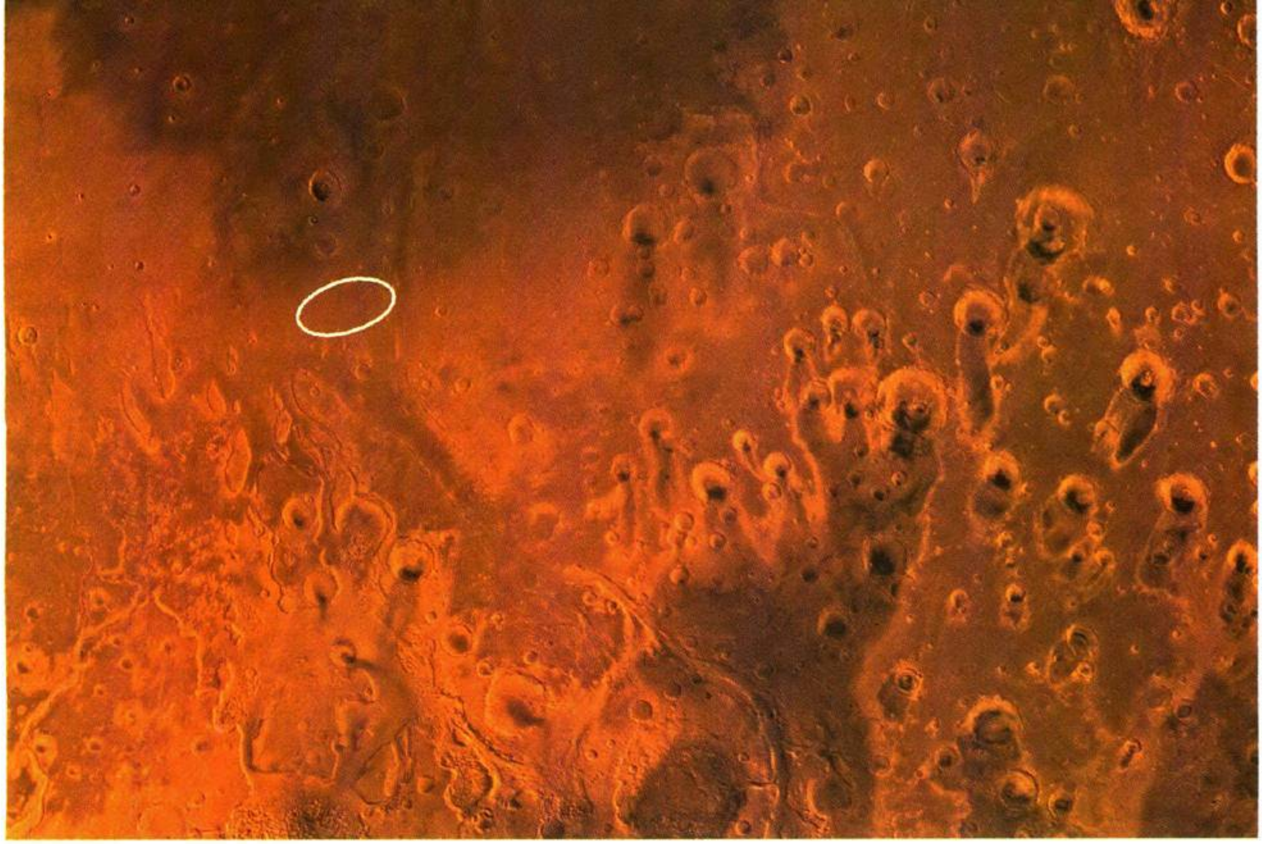
November 1996 saw the launch of Mars '96, an orbiter/lander mission begun by the Soviet Union and inherited by Russia. During that time NASA also dispatched its orbiter-only Mars Surveyor on a journey to the Red Planet.

Both spacecraft reach martian orbit next September, with the Mars '96 mother ship dropping two spherical landers and a pair of surface penetrators on its way into martian space. Mars Surveyor's scientific studies, however, won't begin until March 1998, after the orbiting spacecraft takes several dips into Mars' upper atmosphere to hone an orbit ideal for mapping the planet's surface.

Beating them all to the prize by a full four months is Mars Pathfinder, a combination lander/rover sent aloft in early December, several weeks after Mars '96 and Surveyor began their journeys. Like a fastball from Earth, Pathfinder arcs directly to the martian surface itself, alighting with a wallop on a cushion of airbags on July 4, 1997.



Humanity's first roving emissary to Mars lands on the Red Planet this July 4.



Unless otherwise noted, all photos, NASA/JPL

Rivers drained into Ares Vallis billions of years ago. A 100- by 200-kilometer oval marks the area where Mars Pathfinder will touch down.

Cruising the Plains of Mars . . . Finally

Pathfinder's payload is twofold. It delivers a lander with cameras and instruments to study the martian landscape and its weather conditions, and a tiny, six-wheeled rover designed to roam dozens of meters from the parent lander.

By imparting mobility, Pathfinder's rover, dubbed "Sojourner" by mission planners for someone that stays for a time before moving on, will fulfill the dreams planetary scientists have had since the Viking landers return images of Mars' rocky surface in 1976. It will let Earthbound controllers explore what lies beyond the eyes of a stationary lander.

Sojourner itself is by most accounts just an elaborate engineering experiment, an "all-up" test of a concept first proposed soon after Viking landed on Mars.

If the rover works beyond a hoped-for seven-martian-day nominal lifespan and continues to function for 30 more days, its design will form the cornerstone of more trips to the Red Planet on missions planned through 2003. A proven Sojourner concept may someday fly to other planets and moons in the solar system.

But first, Mars.

Crammed into Sojourner's tiny, 16-kilogram shoebox frame are three cameras, an onboard autonomous navigation system, and an instrument that tastes the chemistry of nearby rocks.

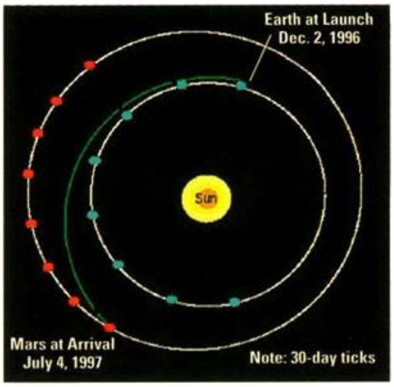
This payload — and six electric motors that power each of the rover's wheels — gets energy from the Sun, courtesy of a solar panel that blankets the rover's top. An appetite for solar energy means Sojourner can only traverse terrain between 10 a.m. and 2 p.m. local time, when the Sun hangs high in the Martian sky.

Under the pink, sun-splashed sky, the rover's miniature cameras will return detailed color and black-and-white photos of rocks and soil, showing details less than a millimeter across. To geologists, this high-fidelity photography will be like taking a magnifying glass to Mars.

Another Sojourner experiment — referred to as APXS for Alpha Proton X-ray Spectrometer — sits on a retractable, steerable boom tipped with a radioactive source that bathes anything it touches with what are called Alpha particles.

APXS looks for any Alpha particles that reflect back, deducing the mineralogical nature of martian rocks and soils rather like you would determine a building's features by dousing it with a fire hose and noting how much water gets splashed back from windows, shutters, and doors. The instrument will also detect any elements in a sample that emit signature protons or X rays.

Even Sojourner's creep across the surface gets wrung for science. Controllers will carefully monitor how hard each of the rover's six wheel motors must work to roll the rover along. Soil dynamicists



Pathfinder coasts out to the orbit of Mars after a December, 1996 launch.

will use this information, along with careful analysis of photos of the rover's tire tracks, to deduce the martian soil's mechanical properties.

Under a Lander's Watchful Eye

Minding its charge from a distance is Sojourner's mother ship, the Mars Pathfinder lander. The lander cradled Sojourner during its seven-month journey to Mars. The dormant rover was stowed against one of three petals that unfolded after the landing took place on exterior airbags. After the bags deflated, the lander righted itself and unfolded its petals. One petal has solar panels; another, an antenna to talk with the rover. A third petal harbors the rover itself on a ramp. Two spring-loaded masts, one capped with cameras and the other bristling with weather instruments, pop up from the lander's body after touchdown.

Immediately after landing, the cameras radio panoramas back to Earth of the surrounding landscape before Sojourner sets out to explore at a snail's pace of 0.4 meters per minute, a little less than one mile per hour.

Controllers on the ground use stereo pictures taken by the lander to carefully plan Sojourner's course over a four-hour period. The preplotted route gets radioed up from Earth to the lander, which in turn hands off the detailed instructions to the rover.

Sojourner is then on its own, inching along to negotiate rocks as tall as 13 centimeters. It's not doing this blindly, however. Onboard lasers scroll out a pattern along the route just ahead, providing Sojourner's computer with the ability to see itself around any unexpected pitfalls ground controllers might have missed. Bear in mind that radio signals will take more than 10 minutes to get to Earth from Mars during Pathfinder's mission. Such on-board prudence is convenient at best, if not a downright necessity for survival.

All this happens within site of the lander, whose cameras photograph Sojourner's precise location after a day's crawl. With those photos, ground controllers plan the next day's travel. This cycle of picture, plan, radio, traverse, and feedback gets repeated each day until the rover stops working entirely. The routine could carry Sojourner up to 100 meters from the lander in 30 days' time.

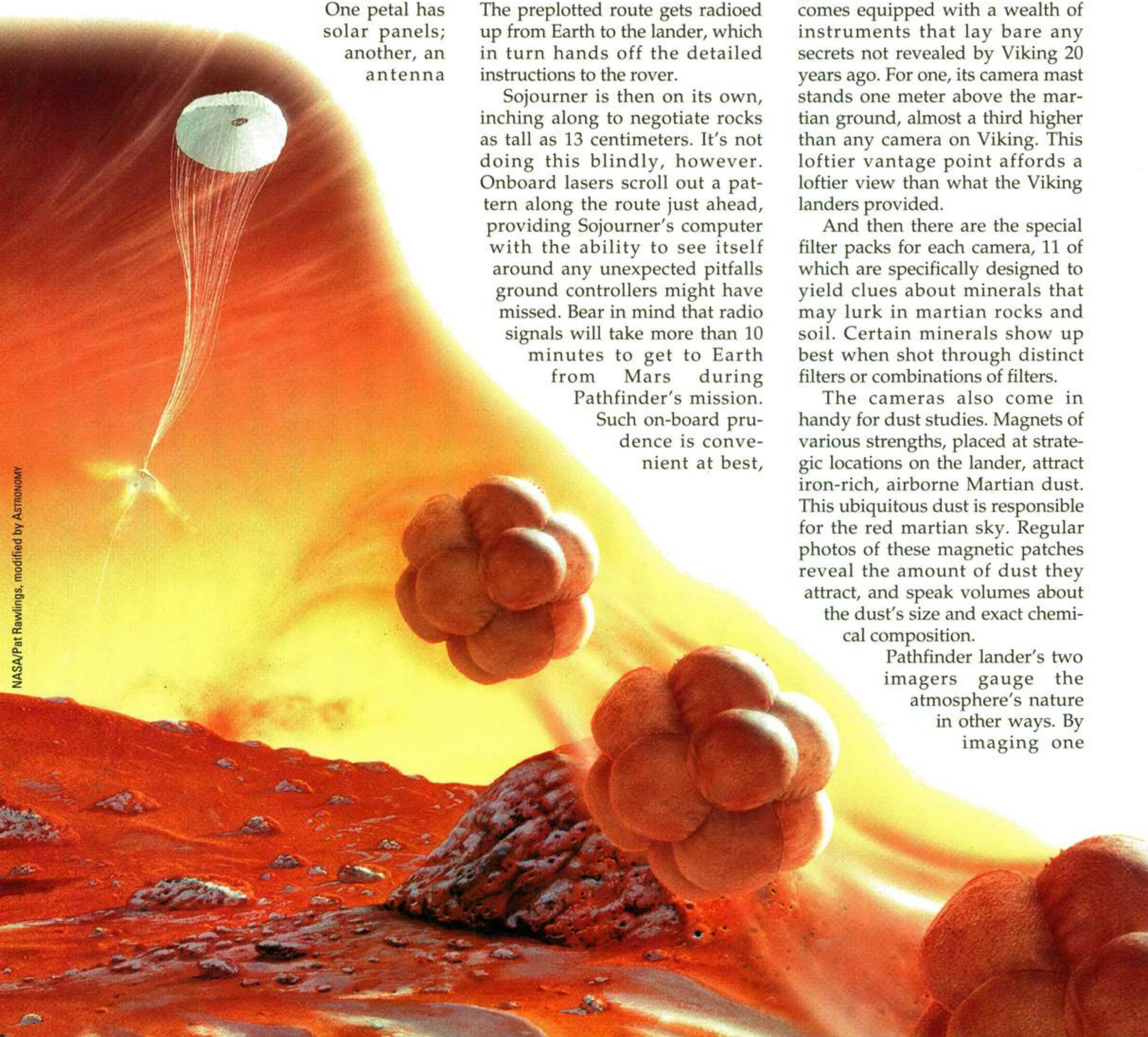
Beyond Mother Hen

But the lander isn't just relegated to a support role; it, too, comes equipped with a wealth of instruments that lay bare any secrets not revealed by Viking 20 years ago. For one, its camera mast stands one meter above the martian ground, almost a third higher than any camera on Viking. This loftier vantage point affords a loftier view than what the Viking landers provided.

And then there are the special filter packs for each camera, 11 of which are specifically designed to yield clues about minerals that may lurk in martian rocks and soil. Certain minerals show up best when shot through distinct filters or combinations of filters.

The cameras also come in handy for dust studies. Magnets of various strengths, placed at strategic locations on the lander, attract iron-rich, airborne Martian dust. This ubiquitous dust is responsible for the red martian sky. Regular photos of these magnetic patches reveal the amount of dust they attract, and speak volumes about the dust's size and exact chemical composition.

Pathfinder lander's two imagers gauge the atmosphere's nature in other ways. By imaging one



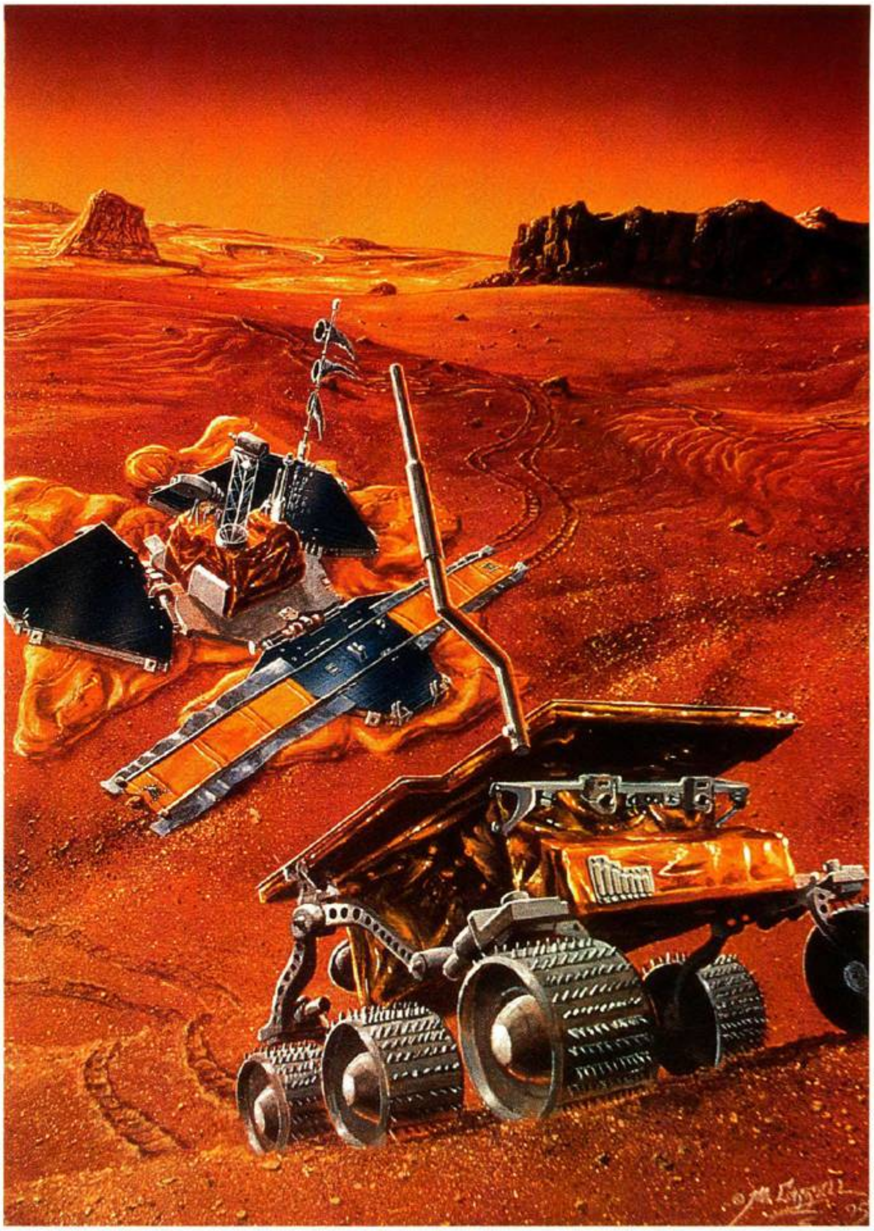
NASA/Pat Rawlings, modified by ASTRONOMY of Mars' moons, Phobos, at night, scientists can glean how much dust lies suspended in the martian atmosphere. And special filters let the cameras look directly at the Sun to judge the sky's opacity during the day.

But the atmospheric studies don't end there. At several times during the day, lander cameras photograph windsocks placed on the meteorology mast at six different levels. Monitoring how these socks blow yields important clues about prevailing martian winds and lets aerodynamicists model air flow characteristics of the surrounding terrain.

Sensors that read air temperature at three levels up the mast supplement meteorology investigations. Crowning the mast is a sensor that measures wind direction. Never before have meteorologists had at their disposal on Mars a weather package of such complexity. Where Viking measured just wind speed, direction, and temperature at a fixed height, Earthbound Pathfinder weathermen will get a three-dimensional feel to how a paltry ocean of air — mainly rarefied carbon dioxide — ebbs and flows around the lander.

A New Dawn for Martian Exploration

When Mars Surveyor begins its orbital reconnaissance of the Red Planet in March 1998, Pathfinder lander might be halfway through an extended mission that carries it through September. Surveyor's high-resolution imaging and its accurate determination of the shape of Mars, plus the mission's first-ever measuring of whatever magnetic field the Red Planet might have, dovetails perfectly with surface studies undertaken by the Mars Pathfinder lander and rover. Such a collaboration is just a taste of what lies ahead.


NASA/Michael Carroll

Sojourner slowly moves away from its mother ship, keeping in constant contact through a radio antenna. The lander relays information between the rover and Earth, besides conducting science of its own.

Future Surveyor flights that launch every two years through the year 2003 will combine the global views of an orbiter with the regional, close-up insights provided by a lander/rover duo. Rover missions will range the martian polar regions or traverse ancient riverbeds. A future lander/rover mission might even return a martian rock sample to Earth for study as early as 2001.

Such capabilities will certainly build upon the tried-and-true technology embodied in Sojourner and its mother lander. What started this year as a testbed should give planetary scientists in the 21st century a luxury of mobility that will yield dividends when it comes to selecting strategies in the search for potential martian life.

The search won't be shackled to one spot, on one corner of a Martian plain. It will move among the most promising places on Mars, all thanks to the legacy of a martian rover that hit the ground with all six wheels running, a little rover named Sojourner. ☐

Associate editor John Shibley was a high school student when the last mission to Mars' surface culminated with a landing in 1976.

After slowing down with rockets and a parachute, Pathfinder severs a tether and makes its bouncy landing on airbags.

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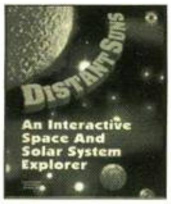

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EXTREME STARS

At the Edge of Stellar Behavior

From tiny balls no larger than a city to swollen giants that would fill up the inner solar system, stars come in an amazing variety of sizes, temperatures, and luminosities.

by James B. Kaler

They shimmer around us, sparkling grains of quartz tossed against the nighttime sky. At first, they seem similar, tiny points displaying only differences in brightness and subtle variations in color. Over the past 200 years, however, astronomers have slowly revealed their true natures. Far more than a simple evening delight, the stars are perhaps the proprietors of other planetary systems and the keepers of life.

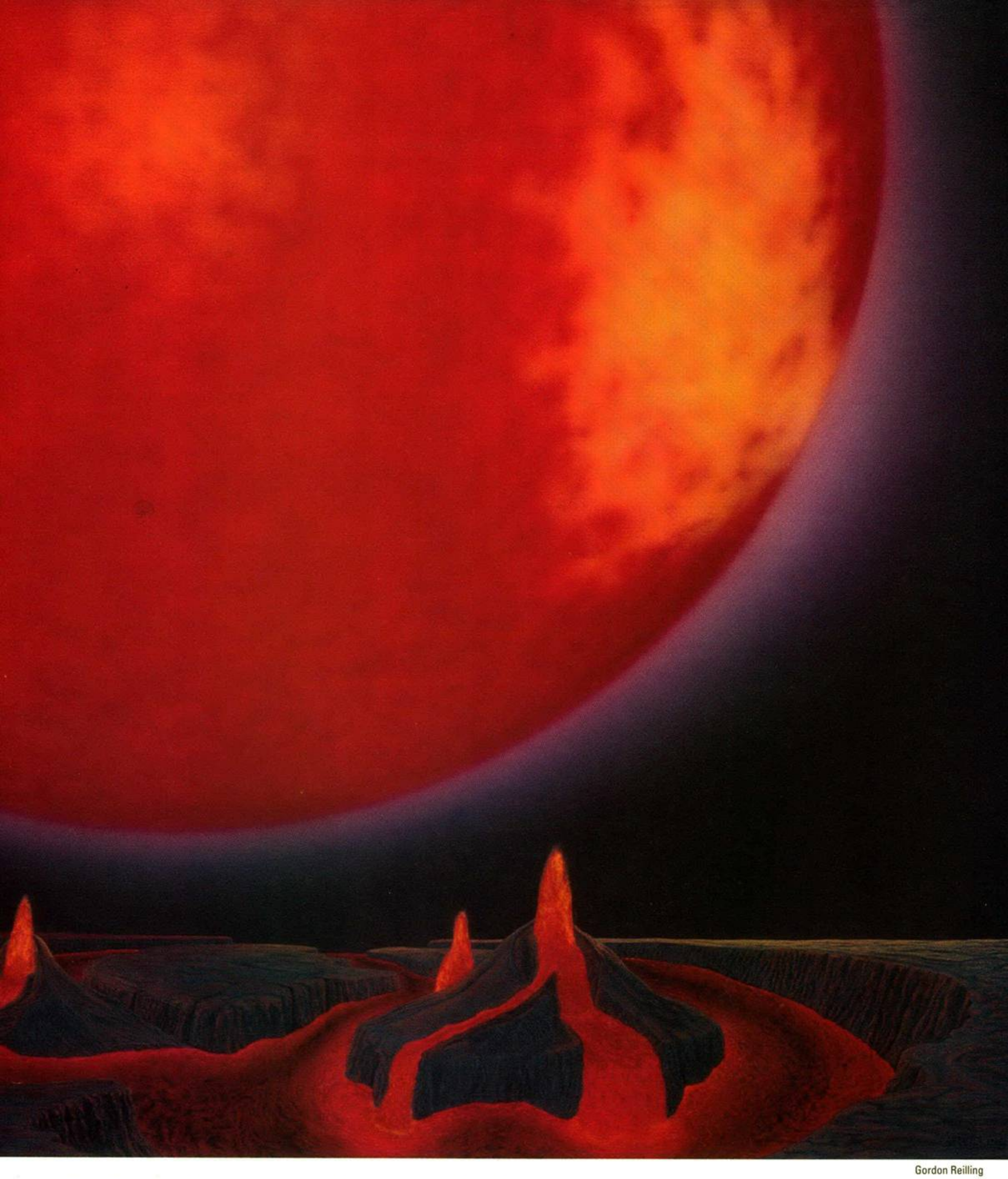
Along with their great importance go spectacular extremes of size, temperature, and luminosity. In one of nature's most ironic twists, one extreme may be followed by its opposite, the coolest stars becoming the hottest and the largest the smallest. By understanding these transformations astronomers have pieced together the story of how stars live and die.

Limits to Size

Let's begin with our Sun as a reference: 109 Earths could be stretched along its diameter and its volume could hold a million terrestrial worlds. The Sun's mass is 300,000 Earths and a thousand times that of the king of the planets, Jupiter. From its 6,000-kelvin surface, energy pours out at a rate of 4 x 10^{26} watts, the equivalent of over 10 trillion trillion standard 100-watt light bulbs. The cost of running the Sun for one second by your local power company would equal the gross national product of the United States accumulated over a million years. Moreover, this rate of energy production has been sustained for the 4.6 billion-year lifetime of the solar system. This remarkable energy output is produced by the fusion of hydrogen into helium deep in the Sun's hot (15 million-kelvin) core. Astronomers calculate that the Sun started with a 10-billion-year supply of hydrogen. The Sun is 4.6 billion years old, so it should last for another 5 or so billion years.

Though commonly touted as an "average" star, the Sun is considerably larger, hotter, and brighter than most. But as impressive as our star is, many are much grander in all their aspects. But what do we mean by "grand"? When we speak of impressive qualities, we commonly think in terms of the large. Small, however, can be impressive as well.

Stars are characterized chiefly by their diameters and their surface temperatures. Together these properties determine the third principal characteristic, luminosity. The range of stellar diameters is perhaps most astonishing. Pluck a few stars down from the nighttime sky, beginning with spring's Arcturus or winter's Aldebaran. These orangy "giant stars," not



Gordon Reilling

just a description but also a name for a type, are respectively 20 and 40 times larger than the Sun. Stars like the Sun are called "dwarfs," hardly an apt term, merely to distinguish them from these giants.

Arcturus and Aldebaran pale, however, beside larger but less-easily visible stars like reddish Mira in the heart of Cetus, the

Betelgeuse looms large in the sky of a scorched planet. This star would fill the solar system past the asteroid belt.

Whale. Mira is a long-period variable, typical of a yet-larger class of giants. The star is normally invisible to the naked eye, but every 11 months it brightens to roughly third magnitude, about as bright as the faintest star of the Big Dipper. Mira's variation in brightness is in part the result of expansion and contraction. If Mira were magically transported to the Sun's location, it would fill out the inner solar system beyond Earth even at its smallest size. At its largest, the star would approach the orbit of Mars and would be 150 times the solar diameter.

But we are not nearly at the limit. Two reddish jewels, Betelgeuse in winter's Orion and Antares in summer's Scorpius, belong to a different category altogether. Both of these "supergiants" would fill our solar system well past the orbit of Mars, with Betelgeuse (twice Antares' size) stretching to near the orbit of Jupiter.

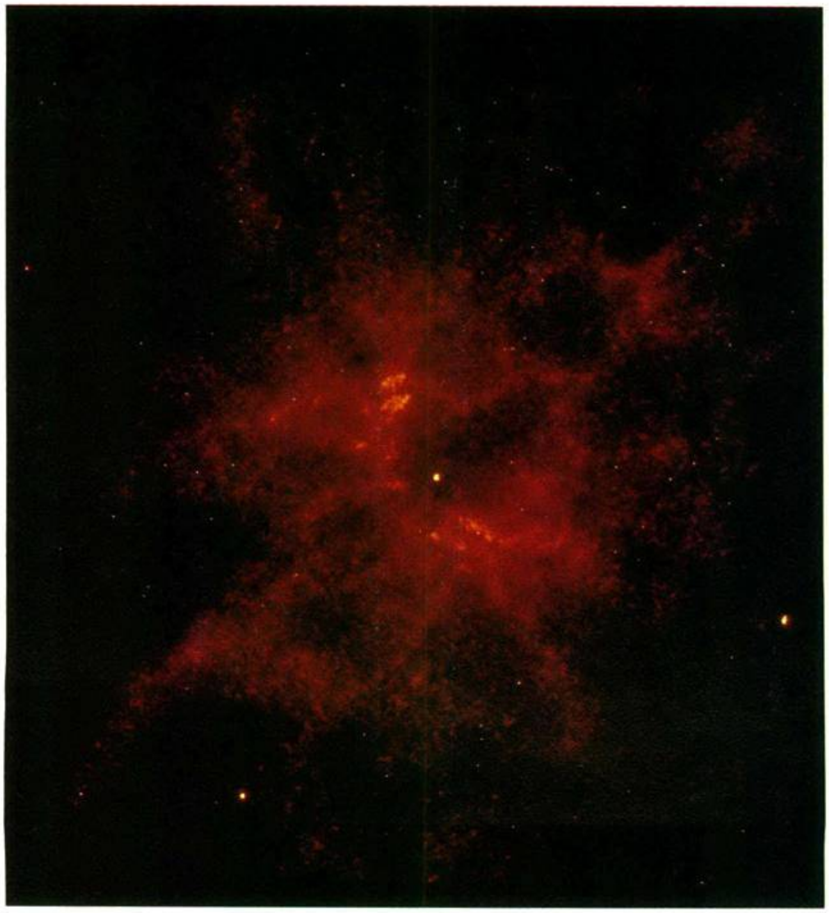
And we are still not at the end. In Cepheus gleams Mu (μ) Cephei, impressively reddish through binoculars. One of the largest stars known, Mu Cephei's diameter is crudely comparable to the orbit of Saturn, over 1,000 times the diameter of the Sun. It could hold a billion Suns.

Now let's go in the other direction, from the large to the small. The nearest star — only 4.2 light-years away — is a red dwarf called Proxima Centauri. It's diameter is only 1⁄10 that of the Sun. Below Orion sparkles the night sky's brightest star, Sirius. Tucked next to it is a dim companion 10,000 times fainter than Sirius itself, each star in orbit around the other. The faint component, Sirius B, is the size of Earth and can be seen only in large amateur telescopes. The Sun could hold a million Sirius Bs, and Mu Cephei could contain a million billion. The first of this strange breed to be discovered was white in color, hence the whole class of such stars came to be known as "white dwarfs" (even though some are blue and others orange) to distinguish them from solar-type "dwarfs."

We can go yet smaller. Off the southern horn of Taurus is a dim cloud of gas, the Crab Nebula. Within it lies a strange star that produces 30 bursts of radiation per second at extraordinarily regular intervals. Precision timing suggests rotation, and fast rotation can only take place in something very small. This tiny star is beaming radiation like a lighthouse, and the beam sweeps past Earth every rotation. These small stars — called neutron stars — are densely packed balls made nearly exclusively of neutrons (the neutral particles that help bind atomic nuclei). Neutron stars are no more than 30 kilometers or so across, the size of a small city. We could line up 50,000 neutron stars across the solar diameter. The Sun could contain 100 quadrillion (10^{17}) of them and Mu Cephei an uncountable (10^{23}), which is more than all the stars in the visible universe!

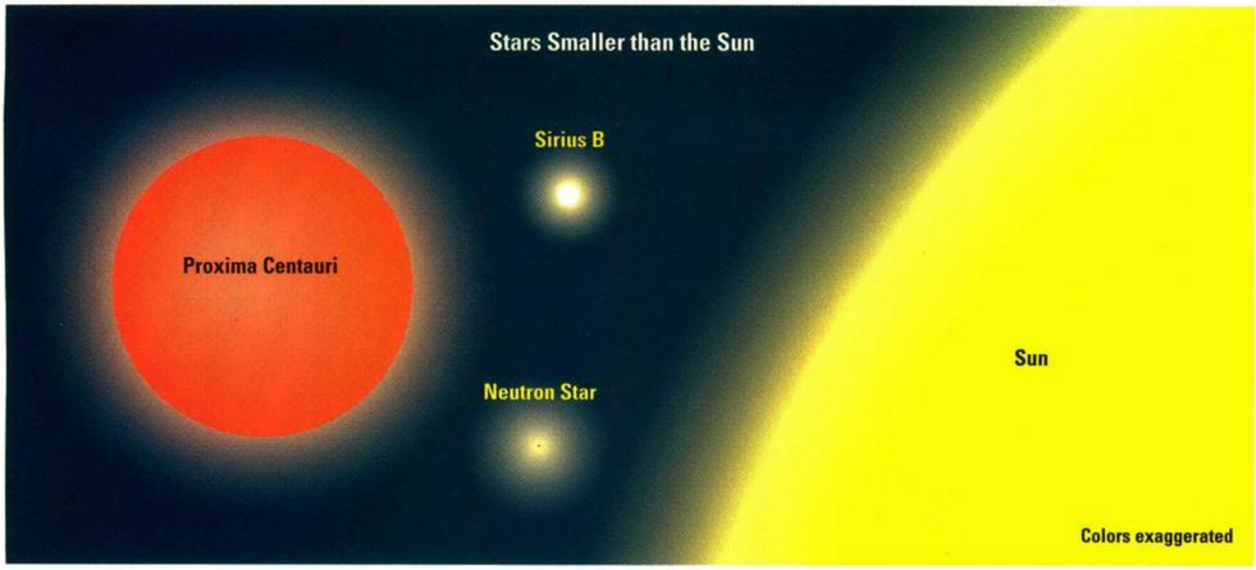
Limits to Temperature and Luminosity

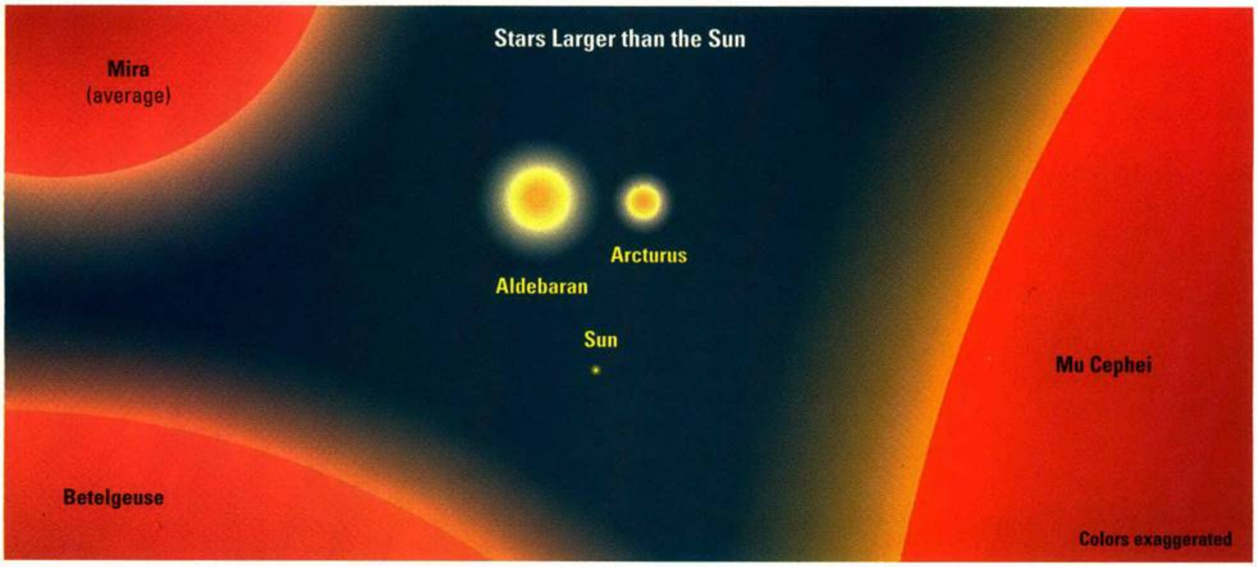
While the range of stellar surface temperatures is not so great as that of sizes, it is still impressive. The color of a star, or any other dense glowing body, correlates with temperature. As you heat a bar of iron (or if you could heat a star) it glows red at a temperature of 1500 K, turns orangy at about 4000 K, yellowish-white at 6000 K, and white at 10,000 K. Much hotter than that and the body takes on a bluish cast. Because the Sun's temperature is about 6000 K, sunlight has a soft yellow-white glow. Aldebaran and Arcturus — and the other ordinary giants — typically have relatively cool surface temperatures of 4000 K, giving them a yellow-orange cast. The reddish supergiants Betelgeuse and Antares go down to 3500 K. The lowest surface temperatures are reserved for the large giants of the Mira class, which can drop to 2000 K or lower.



Sally Heap (GSFC) and NASA

One of the hottest known stars, a white dwarf with a temperature of at least 200,000 K, lies at the center of this Hubble Space Telescope image of planetary nebula NGC 2440.





ASTRONOMY: Lee Vande Visse

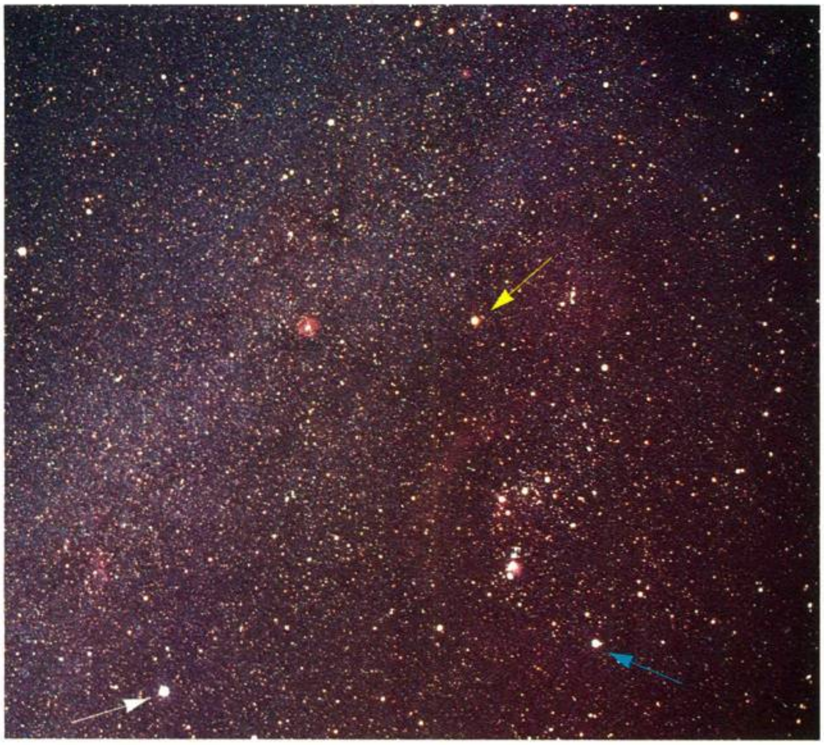
In the opposite direction we find other dwarfs: white Sirius and summer's Vega, with surface temperatures of about 10,000 K, and Orion's Rigel — a blue supergiant — at 20,000 K. Higher yet is the brightest star in the center of the Orion Nebula, located at the center of the Hunter's sword, which tops 45,000 K. The high-temperature limit is reached in the central stars of the lovely gas clouds called planetary nebulae. They start at 25,000 K and climb to an observed maximum of nearly 250,000 K, over 40 times hotter than the Sun's surface.

The amount of energy pouring out of a body's surface hinges critically on its temperature. Hot bodies naturally radiate more energy than cool ones, the output power per square meter depending on the fourth power of the temperature: double it and the radiant luminosity goes up by a factor of 2 x 2 x 2 x 2 = 16. The luminosity of a body also depends on how big it is, or on the number of square meters that radiate light. The total luminosity therefore depends on the product of surface area and temperature. If we know temperature and diameter (from which we can calculate surface area), we can thus determine the luminosity. Conversely, if we know luminosity and temperature, we can calculate the diameter. Much of our knowledge of stellar sizes comes from just such a procedure.

The range of stellar luminosities is staggering. The red supergiant Mu Cephei is nearly a million times more luminous than our Sun. At the other end of the luminosity scale, we find red dwarfs a million times fainter than our Sun. These dim bulbs could be seen with the naked eye only if brought within 200 times Pluto's distance.

Origins

The origins of these variations in size, temperature, and luminosity lie in the combination of mass and age. The course of a star's life is set by the amount of matter given to it at birth. The wide range of physical characteristics among dwarfs, all of which have similar chemical compositions, is actually caused by their wide range of masses. Dwarf stars like the Sun are defined as those that are

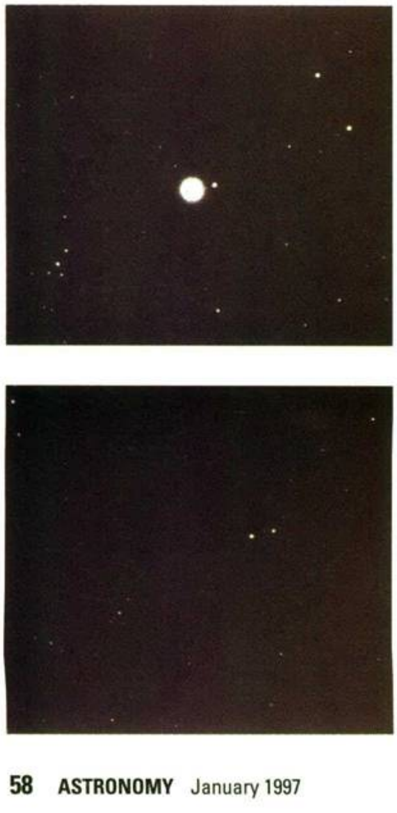


Terence Dickinson

A wide-angle view of Orion shows the red supergiant Betelgeuse (yellow arrow), the blue supergiant Rigel (blue arrow), and Sirius (white arrow) – the bright companion to a white dwarf.

producing energy by the nuclear fusion of hydrogen into helium. Dwarf masses range from about 0.08 that of the Sun to about 100 times solar.

Stars at the upper end of this mass range have more gravitational energy, and are consequently hotter and denser inside. Higher temperature means a higher rate of energy production and thus greater luminosity. Double the mass of a star and it becomes roughly 10 times brighter. A 100 solar-mass dwarf is approximately a trillion times brighter than one of 0.08 solar masses.



Lowell Observatory

The red giant Mira brightens and fades in the constellation Cetus as it expands and contracts. At its largest, Mira would fill up the inner solar system.

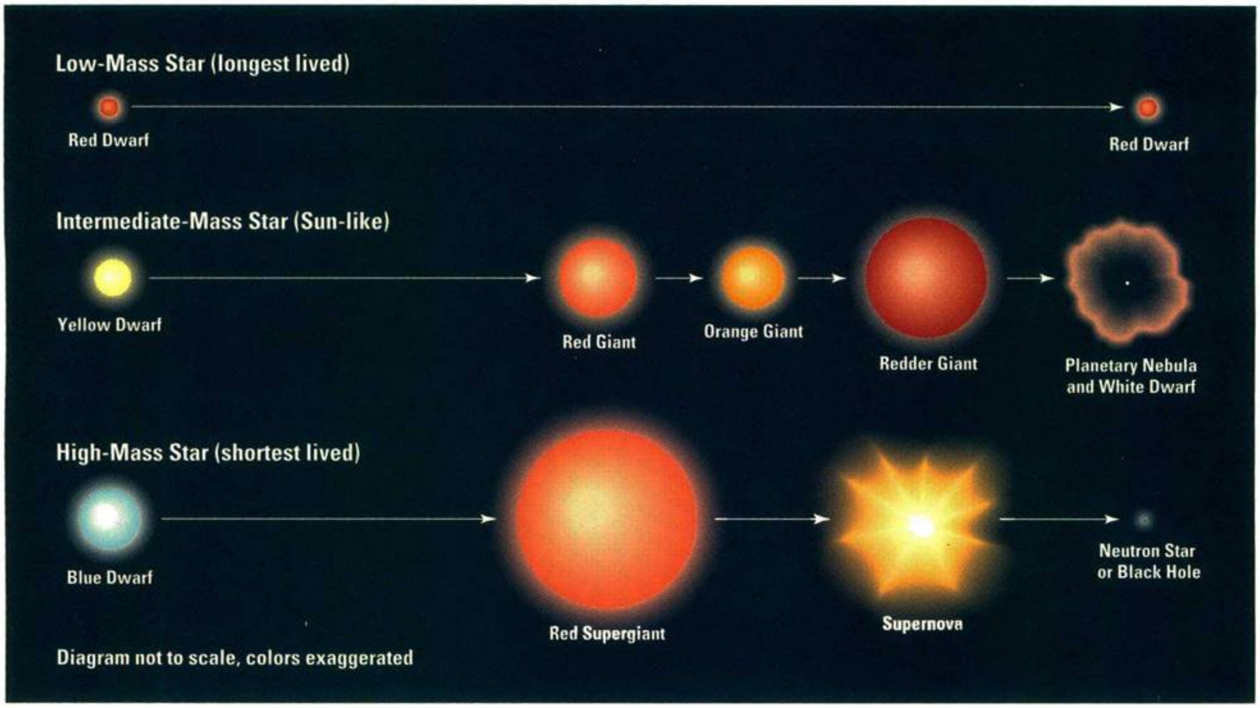
All the other categories of stars arise from the aging of the dwarfs as they almost magically transform themselves under the inexorable force of gravity. When the giants and supergiants were first distinguished from the dwarfs in the early part of the century, it seemed only logical that stars ought to be born large and then squeeze down into the smaller varieties. Therefore giants and supergiants should be the youngest. The astronomical pioneers, however, had not realized that most of the gravitational squeeze takes place deep inside the star where it is not immediately visible.

Astronomers gradually worked out the story of stellar evolution over the latter part of this century. The longest-lived stars are the low-mass dwarfs. The lower the mass of a star, the slower the rate of nuclear fusion and the longer the star lives in spite of its smaller fuel supply. The lowest mass dwarfs will live for over a trillion years, far longer than the age of the Galaxy. All the low-mass dwarfs ever born are still shining.

The dwarfs of intermediate mass, those between just under a solar mass and about 8 times the mass of the Sun (the number is poorly known) perversely become the giants. When the hydrogen fuel runs out in such a star, its helium-rich interior shrinks. But the gravitational energy released heats the interior, pushing the outer envelope outward: A giant is born. The giant's core eventually gets hot enough to fuse helium into carbon, the star shrinks and stays alive for awhile. But eventually the helium, too, runs out and the star transforms itself again into an even larger giant like Mira. The intermediate dwarfs thus become the coolest stars.

But while these transformations are taking place, spanning roughly 10 percent the lifetime of the star, the huge star begins furiously losing mass. The outer envelope streams away in a powerful wind, gradually revealing more and more of the intensely hot core. In one of the more remarkable metamorphoses in nature, the coolest stars are thus transformed into the hottest. The cores illuminate the surrounding shells of gaseous mass given off by the previous stellar winds, and the giants become planetary nebulae with hot stellar cinders at their centers.

The central stars of the planetary nebulae continue to shrink, the surrounding gaseous clouds dissipate into space, and the hottest stars become small white dwarfs. Most stars are supported, that is, kept from collapsing under the inward pull of their own gravity, by the outward push of the


Low-Mass Star (longest lived)
Red Dwarf
Red Dwarf
Intermediate-Mass Star (Sun-like)
Yellow Dwarf
Red Giant
Orange Giant
Redder Giant
Planetary Nebula and White Dwarf
High-Mass Star (shortest lived)
Blue Dwarf
Red Supergiant
Supernova
Neutron Star or Black Hole
Diagram not to scale, colors exaggerated

ASTRONOMY: Elisabeth Rowan

pressure provided by their hot gases. The white dwarfs, however, can't shrink further because they are supported by the outward push of densely packed electrons. Their destiny is to shrink and cool forever. But the cooling time is so long, longer than the lifetime of the Galaxy itself, that every white dwarf ever created still glows (see "White Dwarfs Confront the Universe," May 1996).

The high-mass stars, those above 10 solar-masses, have the shortest lives. At the upper limit of about 100 solar-masses, where the stars are also the luminosity record holders (see "Star on the Brink," page 46), fuel is consumed at such prodigious rates that the stars survive for only a few million years, a lifetime only a millionth that of the lowest-mass dwarfs. When their internal hydrogen is all gone, the stars balloon outward to become the huge supergiants. As a result of their great masses, supergiant interiors become so hot that they can carry nuclear fusion past the conversion of helium into carbon, and can "burn" carbon to magnesium, magnesium to silicon, and finally silicon to iron. Iron is the end of the road. No energy can be generated by additional fusion. Instead it takes an input of energy to fuse iron.

Once the iron core develops, fusion stops. The outward push of hot gases from the interior can no longer counteract the inward pull of gravity, so gravity wins in the end. The core collapses, releasing a vast amount of gravitational energy in the blink of an eye. The iron atoms break down ultimately to protons and electrons, which merge, producing a ball of neutrons that squeezes to 30 kilometers across: a neutron star. As the core collapses, it first rebounds, sending a shock wave out into the surrounding envelope. The shock wave and a huge number of nearly massless particles called neutrinos push the envelope outward, creating a cataclysmic explosion — a supernova — that can be seen across vast reaches of the universe.

Dozens of supernova remnants, some in the form of rapidly expanding gaseous ejecta like the Crab Nebula, others blast waves sweeping up interstellar gas, dot the Galaxy. Nuclear reactions gone berserk (as well as those generated in giants) have produced all the atoms heavier than lithium in the universe. As the coolest stars (the giants) transform themselves into the hottest stars (the nuclei of the planetary nebulae), the largest stars (the supergiants) transform themselves into the smallest stars, the neutron stars. Thus we have the seemingly paradoxical situation whereby the larger the star becomes after its initial dwarf state, the smaller it becomes at the end, the result of gravity's great crunch.

Stars can squeeze down even further. The pressure of neutrons in a neutron star can support the star only if the mass is less than two or three times that of the Sun. If the resulting neutron star has a greater mass, it collapses further, in a sense into a point. Ultimately, gravity becomes so powerful that light cannot escape and the "star" — no longer recognizable as such — disappears from view: a black hole. Some of the vast supergiants might thereby plummet into the ultimate in smallness.

The variety of stars in our Galaxy is remarkable, and we might stand in awe of what we see. But if we are to speak of awe, should we not also factor in ourselves? Perhaps more remarkable is that we have the ability to look back upon the stars and understand them and the enormous changes wrought by age. ☐

Astronomer James B. Kaler (kaler@astro.uiuc.edu) studies stellar death at the University of Illinois at Urbana-Champaign. His new book The Ever-Changing Sky *is published by Cambridge University Press.*

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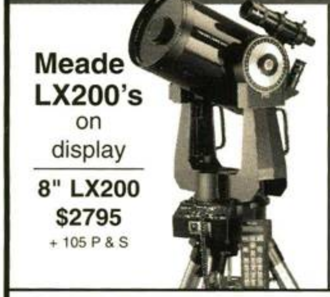

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SKY ALMANAC

Solitary Saturn stands as a sentinel in the southwest after sunset while lustrous stars and a soft Milky Way frame the nebulae of winter.

by Martin Ratcliffe

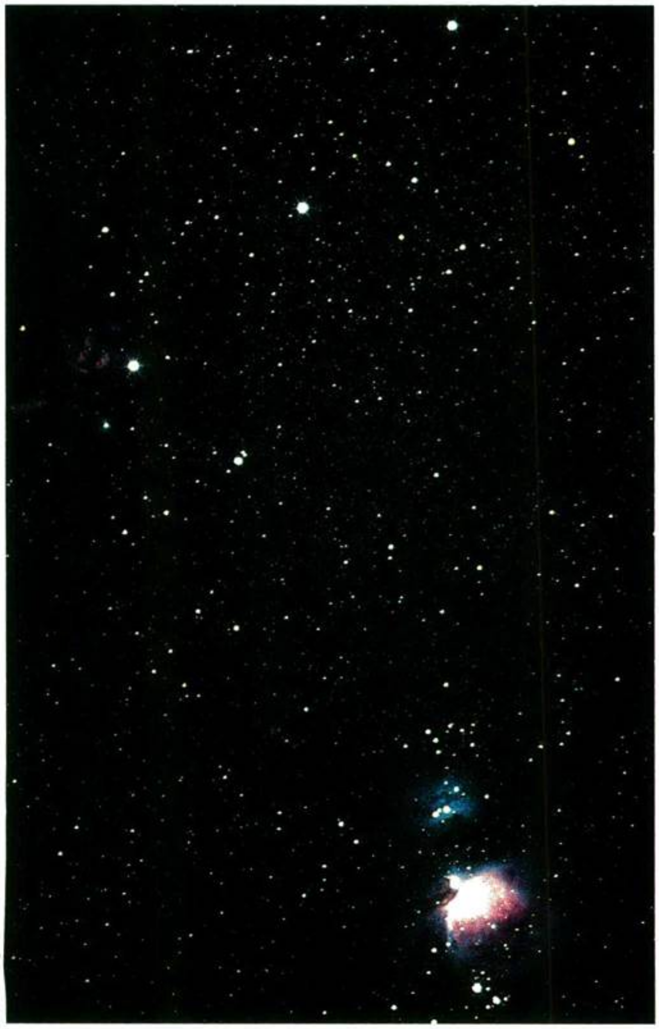
Highlights
by Alister Ling

Date	Event
3	Meteors Streak in the New Year ....(p. 69)
7	Morning's Stuff of Flags ......(p. 69)
11	Evening's Enchanting Crescent .....(p. 68)
13	Isolda Taunts the Crab .....(p. 70)
all month:	**First Views:** Auriga's Big Three Star Clusters ..(p. 67) Hale-Bopp's Northern Exposure ......(p. 70) **Observer's Challenge:** The Double Bubble ....(p. 71)

Orion climbs the eastern horizon as darkness falls on January evenings, its brilliant, jewel-like stars the first to break through the lingering twilight. Three 2nd-magnitude stars lie in a line that rises perpendicularly to the eastern horizon — they represent Orion's belt.

Just 5° south of the belt's central star resides a massive star factory, the Orion Nebula, also known as M42. Under a dark sky, M42 looks like a fuzzy patch of light to the eye.

Binoculars start to resolve its shape, but a small telescope best serves up the cloud's wispy appearance as a midwinter treat. As you take in this scene, bear in mind that light from M42 has taken 1,500 years to reach your eyes, beginning its journey about the time the Roman empire fell.



Glowing gas clouds pepper the region around Orion's belt stars, arranged diagonally across the upper portion of this picture. They range from the sublime Horsehead Nebula, below the left belt star, to the Orion Nebula at the bottom.

Bill Iburg

Last month's Almanac profiled this glowing gas cloud in a project box that gave tips on what to look for in a scope (see "Orion's Magnificent Nebula").

If you've never viewed the glowing tendrils of this premier deep-sky object, January is the month to dress warmly (see "Suit Up for Winter Observing," page 80) and drink in the view, perhaps while sipping hot chocolate.

For observers who enjoy the more sublime, there's M78, some 2½° north-northeast of Zeta (ζ) Orionis, the easternmost of Orion's belt stars. While M42 blazes forth under the radiation of newly igniting stars, M78 feebly reflects light from nearby stars.

Hence it is called a reflection nebula, versus M42's designation as an emission nebula. A 4-inch telescope reveals M78's presence; you'll need a larger scope to glimpse form and structure.

Few observers have glimpsed IC 434, another faint glow that rests below Zeta Orionis. Silhouetted against this dim finger of light is the dark nebula B33, the Horsehead Nebula, an observer's challenge in last month's Almanac (see "The Sublime Horsehead").

Scan for the Horsehead Nebula under a really dark sky while using a telescope of at least 10 inches. Larger scopes will provide a better chance of capturing its presence. Before undertaking your search, wait until Orion is high in the southern sky, which occurs around 10 p.m. this month.

The sky surrounding all this nebulosity bristles with brilliant stars. Orion's 1st-magnitude stars, ruddy Betelgeuse and aquamarine Rigel, are joined by Aldebaran, chief star in Taurus the Bull, charging Orion from the northwest.

As evening progresses, look in the southeast for Orion's friendly canine companion Canis Major with brilliant Sirius, the Dog Star — which is the brightest star in the entire night sky. It shines at mag-

JANUARY

1 Earth is at perihelion (147.1 million kilometers from the Sun), 7 p.m. EST
Mercury is in inferior conjunction, 8 p.m. EST
Last quarter Moon is at 8:45 p.m. EST

3 Quadrantid meteor shower peaks (page 69)

7 The Moon passes 5° north of Venus, noon EST

8 New Moon is at 11:26 p.m. EST

10 The Moon is at perigee (359,233 kilometers from Earth), 3:50 a.m. EST

12 Mercury passes 3° north of Venus, 9 a.m. EST (page 69)

13 The Moon passes 2° north of Saturn, midnight EST

14 Asteroid Ceres is in conjunction with the Sun

15 First quarter Moon is at 3:02 p.m. EST

17 Neptune is in conjunction with the Sun, 8 a.m. EST

19 The Moon passes 0.7° north of Aldebaran, 1 a.m. EST
Jupiter is in conjunction with the Sun, 8 a.m. EST

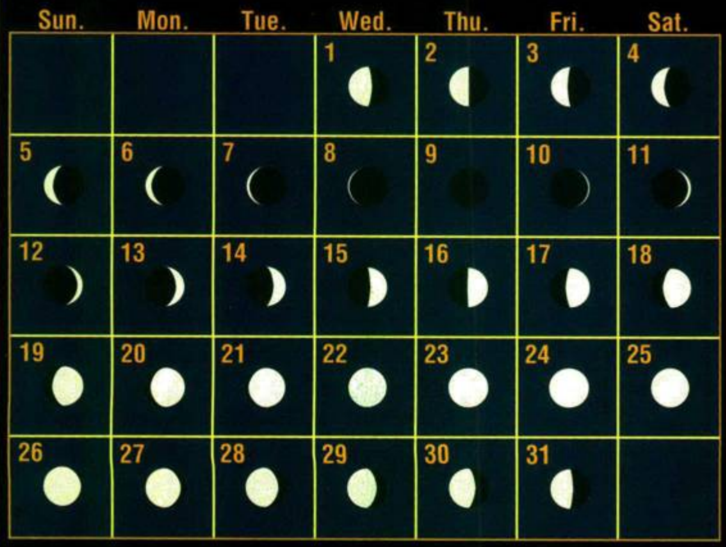
23 Full Moon is at 10:11 a.m. EST
Mercury is at greatest western elongation (25°), midnight EST

24 Uranus is in conjunction with the Sun, 9 a.m. EST

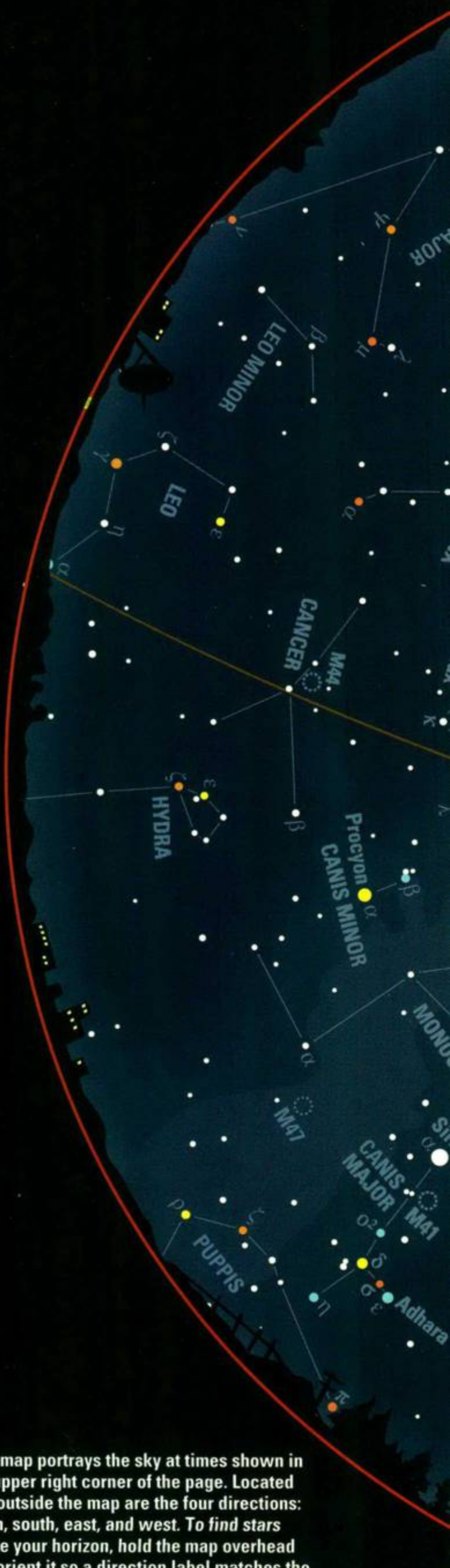
25 The Moon is at apogee (406,224 kilometers from Earth), 11:45 a.m. EST

28 The Moon passes 3° south of Mars, 6 p.m. EST
Mars is at aphelion (249.2 million kilometers from the Sun)

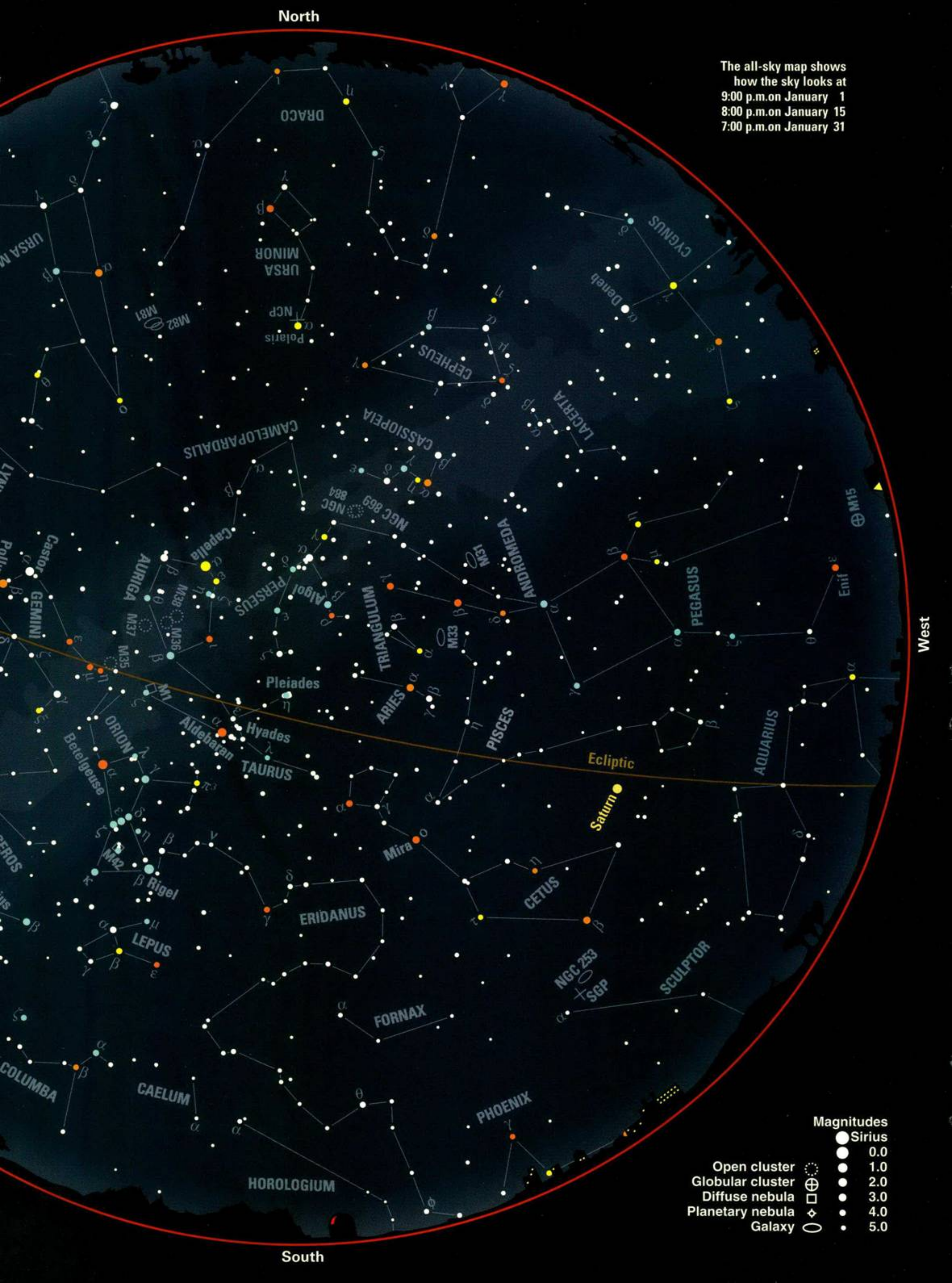
31 Last quarter Moon is at 2:40 p.m. EST



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. *To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.*



The all-sky map shows
how the sky looks at
9:00 p.m.on January 1
8:00 p.m.on January 15
7:00 p.m.on January 31

North
South
West
DRACO
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NCP
Polaris
M81
M82
URSA M
CYGNUS
Deneb
CEPHEUS
LACERTA
CASSIOPEIA
CAMELOPARDALIS
NGC 869
NGC 884
M15
Capella
Castor
Poll
GEMINI
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M38
M37
M36
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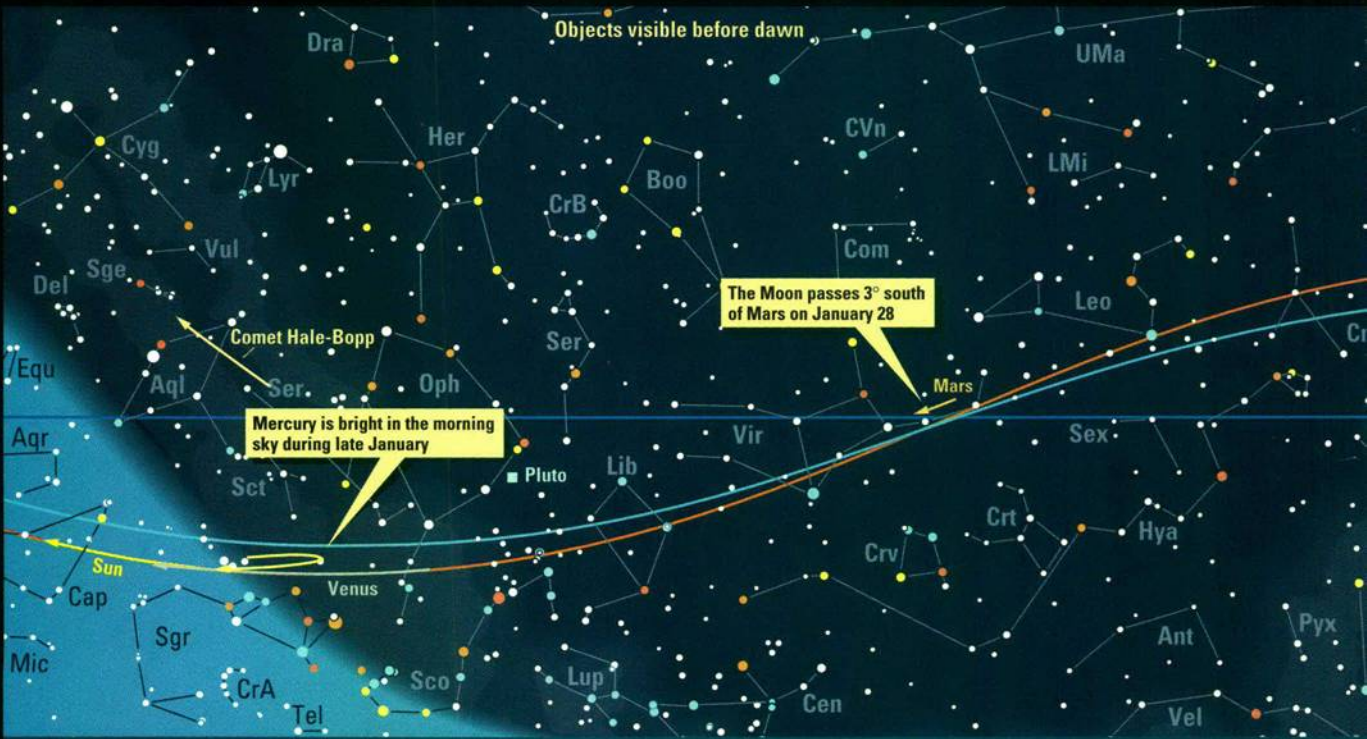
Ecliptic
ORION
Betelgeuse
Aldebaran
Hyades
TAURUS
Saturn
Mira
CETUS
M42
Rigel
ERIDANUS
LEPUS
NGC 253
SGP
SCULPTOR
FORNAX
COLUMBA
CAELUM
PHOENIX
HOROLOGIUM
EROS
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS



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Hya
Cap
Venus
Sgr
Ant
Pyx
Mic
CrA
Sco
Lup
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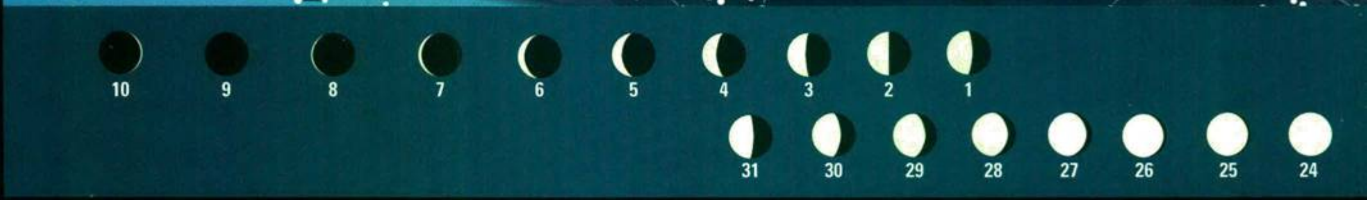
Vel

Objects visible before dawn

The Moon passes 3° south of Mars on January 28

Comet Hale-Bopp

Mercury is bright in the morning sky during late January



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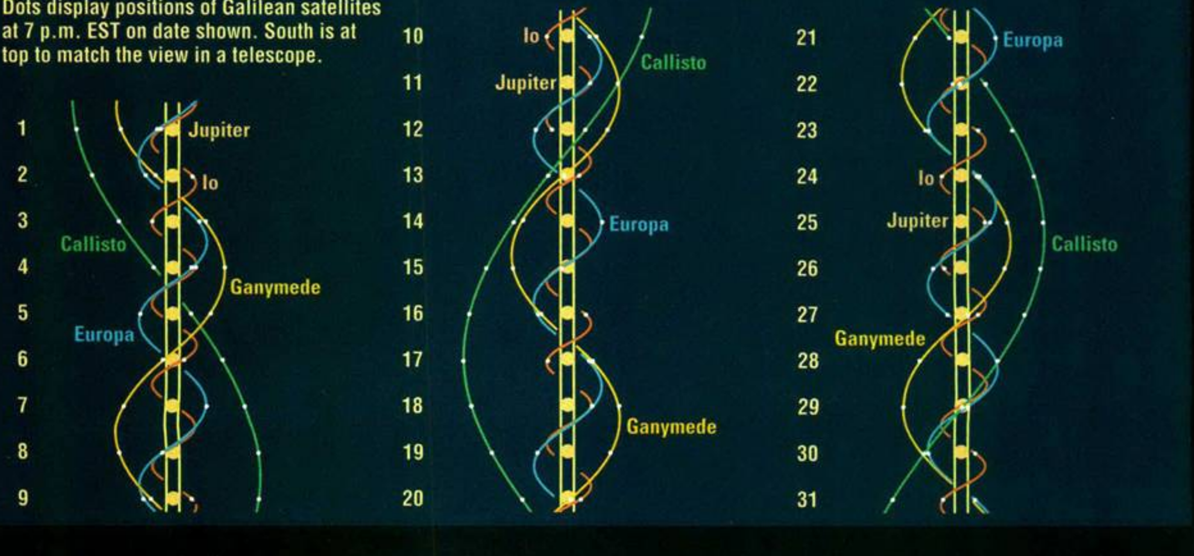
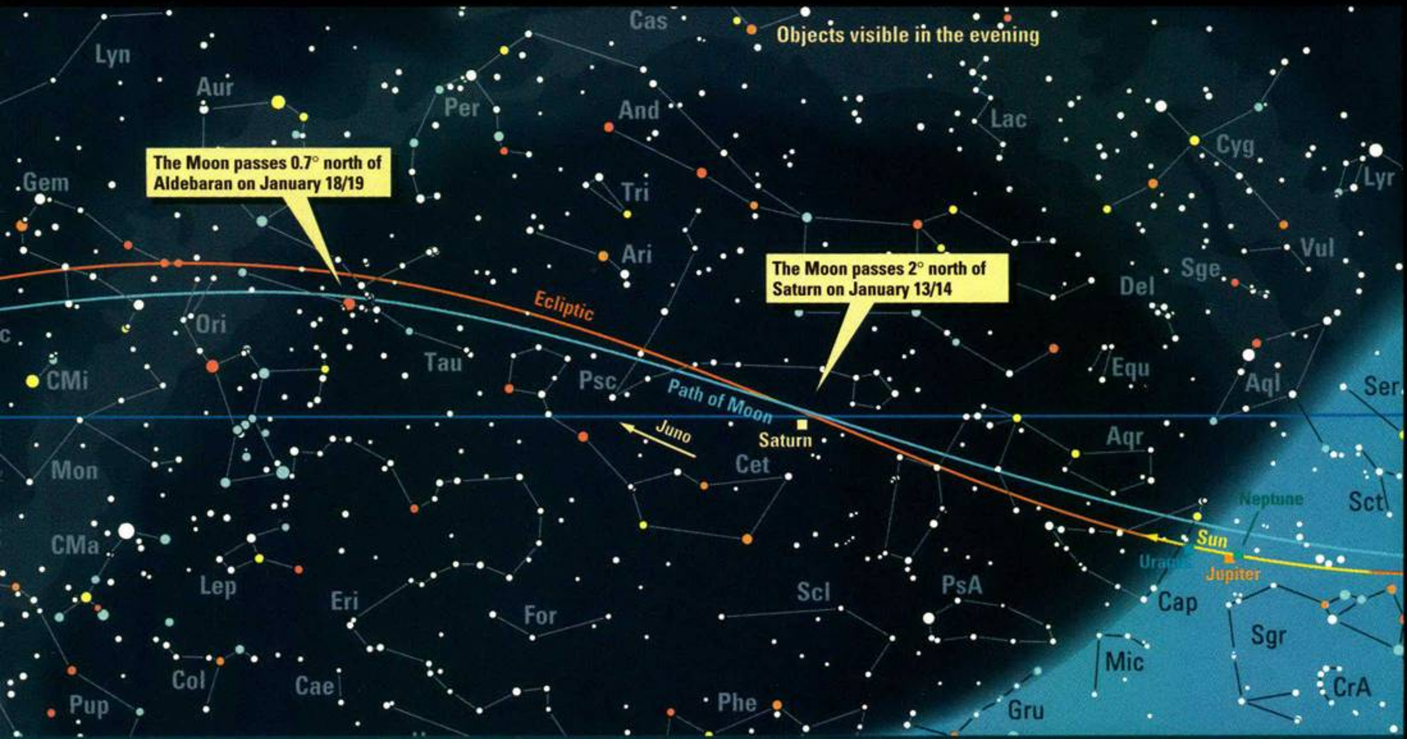
PLANETS	MERCURY	MERCURY	VENUS	MARS	MARS
Date	January 15	January 31	January 15	January 1	January 31
Magnitude	0.2	−0.1	−3.9	0.5	−0.2
Angular Size	8.1"	6.0"	10.5"	8.1"	10.5"
Illumination	39%	74%	95%	91%	94%
Distance (AU) from Earth	0.830	1.117	1.583	1.160	0.889
Distance (AU) from Sun	0.374	0.450	0.726	1.662	1.666
Right Ascension (2000.0)	18h14.2m	19h16.0m	18h26.2m	12h01.6m	12h26.3m
Declination (2000.0)	−20°43'	−22°10'	−23°07'	2°43'	0°46'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 7 p.m. EST on date shown. South is at top to match the view in a telescope.

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Objects visible in the evening
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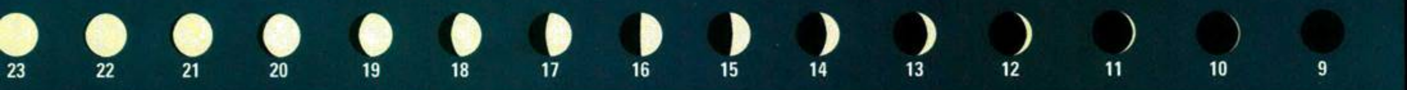
The Moon passes 0.7° north of Aldebaran on January 18/19

The Moon passes 2° north of Saturn on January 13/14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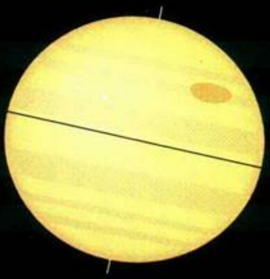
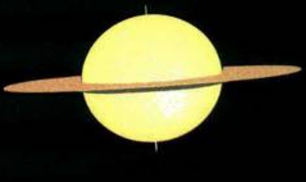
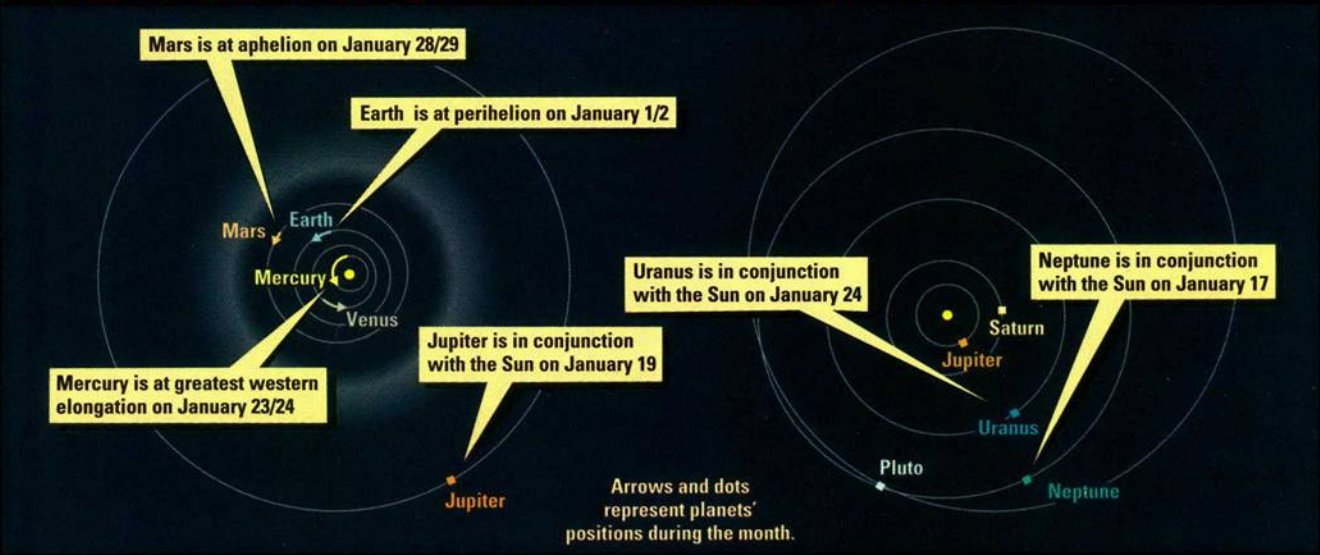




JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
January 1	January 15	January 15	January 15	January 15
−1.9	1.0	5.9	8.0	13.8
32.4"	17.0"	3.4"	2.2"	0.1"
100%	100%	100%	100%	100%
6.083	9.802	20.770	31.138	30.558
5.137	9.467	19.799	30.156	29.951
19h48.9m	0h11.9m	20h26.3m	19h57.5m	16h20.7m
−21°25'	−1°14'	−19°47'	−20°16'	−8°52'

THE PLANETS IN THEIR ORBITS


Mars
Earth
Mercury
Venus
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Mars is at aphelion on January 28/29

Earth is at perihelion on January 1/2

Mercury is at greatest western elongation on January 23/24

Jupiter is in conjunction with the Sun on January 19

Uranus is in conjunction with the Sun on January 24

Neptune is in conjunction with the Sun on January 17

Arrows and dots represent planets' positions during the month.

First Views:

Auriga's Big Three Star Clusters

Summer's Sagittarius may have globs of glowing gas clouds, but winter's Auriga harbors its own sparkling beauty in the form of glittering star clusters.

There's no better way to view the Charioteer's magnificent vista than with a pair of binoculars. They provide just the right amount of magnification to show us splashy fields overflowing with bright stars suspended on the Milky Way's faint but rich backdrop.

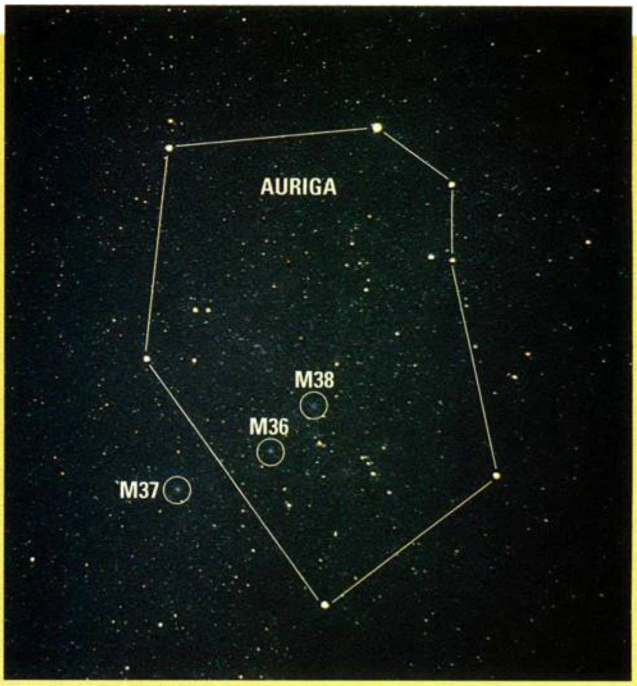
A dark sky away from moonlight and city light pollution will give you the best views of Auriga's riches. Three bright star clusters in particular jump out among the hundreds of faint stars.

The first obvious one, M38, lies smack in the middle of Auriga's vertically stretched pentagon. This star cluster was the 38th entry in 18th-century comet hunter Charles Messier's catalog of comet look-alikes.

When this French observer looked through his small telescope with poor optics at this and two other clusters in Auriga, they looked frustratingly like comets. Even a modern-day set of binoculars held steady will begin to grasp M38's nature, revealing pinpoints of light.

In the same binocular field, but 2° away glows slightly brighter M36. Shift your sight four more degrees to the east — with M36 snugged to the edge — and the delicate glow of M37 comes into view. If you lose your way to M37, try aiming halfway between the two easternmost stars of Auriga's star pattern, and easing just a bit to the east.

A small telescope uncovers the widely divergent character of each star cluster. M37 has the faintest stars, all identical except for one central, orange-hued luminary. M36 contains mostly bright stars, some grouped in pairs. M38's stars run a gamut of brightnesses. If your scope has a primary mirror of 6 inches or more, check out M38's diminutive companion cluster, NGC 1907, just to the south. — *Alister Ling*



Kenneth Paul Fye

Jack Newton

Eugene Brings

Robert Provin

nitude –1.4 to the southeast of Orion's belt. Procyon, Canis Minor the Lesser Dog's anchor star, perches northeast of Sirius.

Skywatchers in the southern part of the United States, south of latitude 37°, will see one more bright luminary below Orion and Canis Major.

Canopus peeks its twinkling aura above the southern horizon due south of Sirius. After Sirius, it's the second brightest star in the night sky.

Shifting our attention northeast of Orion, we come across Gemini the Twins as they swerve to avoid Orion's upraised club. Gemini's twin powerhouses, Castor and Pollux, climb nearly overhead by 10 p.m. to join Capella, a magnitude 0 star in Auriga the Charioteer that lies farther west.

The winter Milky Way, best seen away from city lights, meanders softly through this region of bright stars. Although not as brilliant as its summer counterpart, the winter Milky Way holds many wonderful open star clusters that present plenty of targets for the casual binocular viewer or serious cluster-hunter alike (see "Auriga's Big Three Star Clusters").

Intruding upon this winter scene is one bright star that *isn't*. It sinks in the southwest as Orion rises to prominence in the east. This bright "star" is the ringed planet **Saturn**, which starts the month out at a respectable magnitude of 1.0, shining against the demure constellation of Pisces the Fish.

Saturn and the Fish set 6½ hours after the Sun in early January, slipping below the southwestern horizon at 9:30 p.m. local time by month's end.

Saturn is a "must see" object this month. Small telescopes will reveal the planet's rings and the solar system's second largest moon, Titan.

As if to help you locate the Ringed Planet in the sky, our Moon passes 2° north of Saturn on the evening of January 13.

Over the next few months the Moon's path through this half of the sky creeps farther south against the constellations. Eventually the Moon will occult, or cover, Saturn with each passing.

The same fate has already started to befall Aldebaran, now rising in the east during evening.

The reason our Moon doesn't occult Saturn or Aldebaran every month has to do with Luna's orbit. Its orbital plane is inclined to the Earth's orbital plane around the Sun by 5°.

This means the Moon can appear 5° above or below the ecliptic, the plane of our planet's orbit and nearly that of the other planets in our solar system.

Consequently, over time the Moon traverses a wide area of sky to take in bright stars near, but not directly on, the ecliptic, like Aldebaran, Regulus, Spica, and Antares.

But the Moon doesn't cover these stars every month. Its orbital plane precesses over an 18.6-year period, rather like a spinning hub cap wobbling on level pavement before coming to rest.

Because of this, the Moon's route through the sky is not exactly the same from month to month, or year to year, for that matter. You can monitor precession's effects by noting the Moon's monthly position relative to Saturn and Aldebaran over the coming year.

Luna's precession is leading it through an eclipse season for both Aldebaran and Saturn. In Aldebaran's case, this season won't be repeated for another 18.6 years.

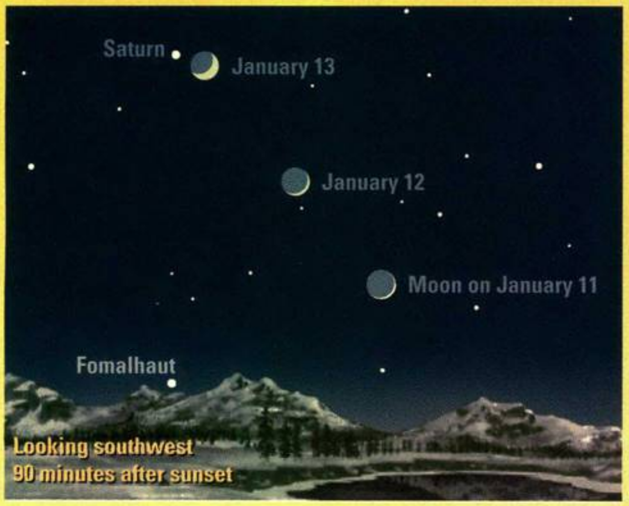
An occultation of Aldebaran happens on January 19, and is visible from Russia, northern Japan, Alaska, Canada, Greenland, and Iceland.

Occultations of Saturn are usually more spectacular, as the Moon gradually blocks out more and more of the rings until the planet finally winks out behind a lunar mountain range. Watch for these in the morning sky beginning this spring.

Incidentally, the Moon reaches apogee, its farthest point from Earth for the month, two days after January 23's full Moon. And while we are on the subject of orbits, Earth comes to perihelion, its closest point to the Sun, on January 1/2.

January also sees our planet line up with the Sun so it blocks three of the solar system's giant planets — **Jupiter**, **Uranus**, and **Neptune** — from view. Jupiter, the brightest of the trio at magnitude –1.9, lies low in the southwest early in the month just after sunset. But it quickly succumbs to evening twilight and passes behind the Sun on January 19. Two days prior to that Neptune is in line of sight with the Sun, followed by Uranus on the 24th. These far-off planets

Evening's Enchanting Crescent



Fabio Falchi

Viewing a young crescent Moon always delights people of all ages. Let your friends and coworkers know when the thin crescent Moon makes its appearance against the glowing evening twilight.

You'll be surprised at how many of them have never noticed the "new Moon in the old Moon's arms."

One such opportunity happens on January 11, when a waxing crescent lies poised above the southwestern horizon. Shift your gaze up a bit to find Saturn; not many novice skywatchers realize that they can actually see it without a telescope.

Luna continues an upward climb the following evening. Be alert for earthshine as the sky darkens. It's the gray, unlit portion of the Moon that's bathed in sunlight reflecting off of Earth's clouds and oceans.

Monday evening, January 13, presents us with a picturesque view of the crescent Moon and Saturn a mere 2° apart. On this evening, light takes only 1.2 seconds to travel to our eyes from the Moon, while Saturn is a distant hour and twenty minutes away by light speed.

Bear in mind that light travels 300,000 kilometers, or 186,000 miles, each second. — *A. L.*

Morning's Stuff of Flags

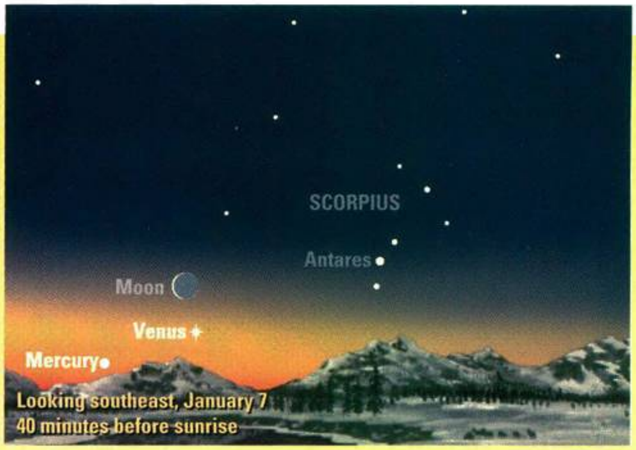
National flags the world over have reproduced for their livery what's gracing the dawn hours of early January. The first full week of 1997 sees a crescent Moon zero in on the brilliant "morning star" Venus to create a lovely pairing during morning twilight.

Nothing else in the sky looks so simple yet majestic at the same time. No wonder the view strikes such an emotional chord in humans.

Closest approach with the crescent Moon is on the morning of January 7. Binoculars are a perfect tool for catching both in the same field of view. Try spotting features on the Moon's unlit portion bathed in earthshine, like oval-shaped Mare Crisium on the disk at 2 o'clock.

This month's pairing happens as Venus closes in on superior conjunction with the Sun. It will soon round the back side of the Sun to remain lost in our day-star's glare for several weeks.

Because Venus lies nearly opposite the Sun from us, its disk will appear small when viewed through a telescope — 11" wide — and display an almost-full phase.



Looking southeast, January 7
40 minutes before sunrise

While you've got binoculars in hand, try locating fleet-footed Mercury rising just as the Sun's glow starts to color the eastern horizon. On the 7th, Mercury lies to the lower left of the Moon/Venus duo.

Use Venus as a guide to locating Mercury throughout the month. At what point can you see the innermost planet without binoculars?

If you have access to a small telescope, watch Mercury go through its phases as January unfolds. — *A. L.*

Meteors Streak in the New Year

One of winter's best kept secrets is the Quadrantid meteor shower. Although it is eclipsed by the active Geminids of last month, the Quadrantids have much to offer.

An observer under a dark sky might see more than 100 meteors an hour before dawn on the morning of January 3. Each flash of light is actually an interplanetary dust speck burning up in Earth's upper atmosphere at speeds of 40 kilometers (25 miles) per second.

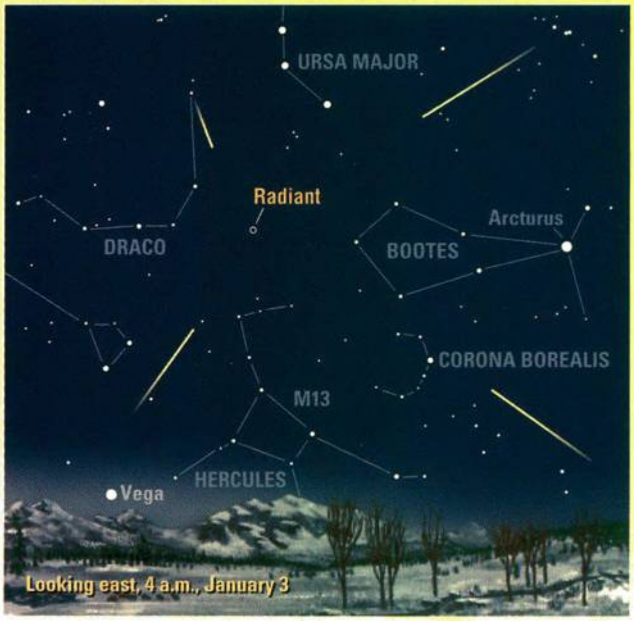
Despite their flashiness, the Quadrantids are often overlooked for two reasons. First, if you miss the predicted peak by five hours, you might see less than one-third the maximum number. This year peak time favors North American observers on the morning of January 3.

Secondly, this midwinter shower is tough to observe in the cold. Clear skies this time of year usually bring frigid temperatures. Fight off the chill by bundling up well, drinking plenty of hot fluids, and by observing with a friend to break up whatever monotony creeps in between meteors.

Break things up by glancing at the waning crescent Moon, just five days from new and hugging the southern horizon on Quadrantid morning.

After glancing at its jagged sunset line through binoculars or a telescope, place the Moon at your back and gaze upon the northern sky with eyes alone. Our Moon's feeble light should not hamper your view of the meteors, which will appear to come from northern Bootes, not far from the handle of the Big Dipper. — *A. L.*

Gert Kroner



Looking east, 4 a.m., January 3

return to our morning sky next month.

Meanwhile, closer to home and in a completely different part of the sky lurks **Mars**. It rises in the east as Saturn sets in the west, climbing higher and brighter towards a March 20 closest approach to Earth. Mars lies within the figure of Virgo the Virgin, where the planet's eastward motion will grind to a halt in early February.

Although this is not the best apparition of Mars — it reaches aphelion, the farthest point from the Sun, on January 28/29 — it is our best view in more than two years.

The very best oppositions occur when the Red Planet is near perihelion. This last happened in 1988, when Mars swelled to an apparent diameter of 23.8".

Mars reached only 13.9" during its last opposition on February 11/12, 1995. This year doesn't fair much better, improving on the 1995 figure by only 0.3".

However, with all the recent interest in its possibility of harboring life, Mars should attract a great deal of attention as it basks in the evening sky.

Isolda Taunts the Crab

It's a rare delight when an asteroid passes close to a Messier object, and what could be more fitting than when one passes so close to Messier number one? The night of January 13/14 sees asteroid 211 Isolda skim a mere 8' away from M1, also known as the Crab Nebula.

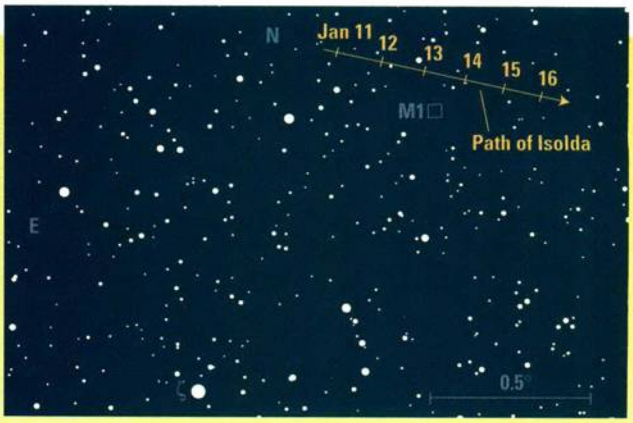
Find the interloper in a telescope by first centering on M1 — it lies northwest of Zeta (ζ) Tauri, the easternmost horn star of Taurus the Bull — and then adjusting your view slightly north to catch drifting Isolda.

CCD astrophotographers might shoot a sequence of frames to show Isolda's motion over the course of a few hours.

As you can see from the accompanying map, Isolda appears to skim the outer reaches of this supernova remnant. In fact, the Crab lies 7,000 light-years behind Isolda, which shines across only 14 light-minutes of interplanetary space.

Isolda is more of a challenge than most asteroid targets because of its 11.7 magnitude. You'll need patience to verify it once you've landed in its field. Figure out which star does not have a corresponding dot on the map, and then wait to see if it moves.

An added bonus for astrophotographers occurs on the night of January 4/5, when magnitude 15.6 asteroid 1417 Walinskia streaks across the north end of the Crab. — *A. L.*



Hale-Bopp's Northern Exposure

The farther north you live, the better chance there is to see Comet Hale-Bopp this month.

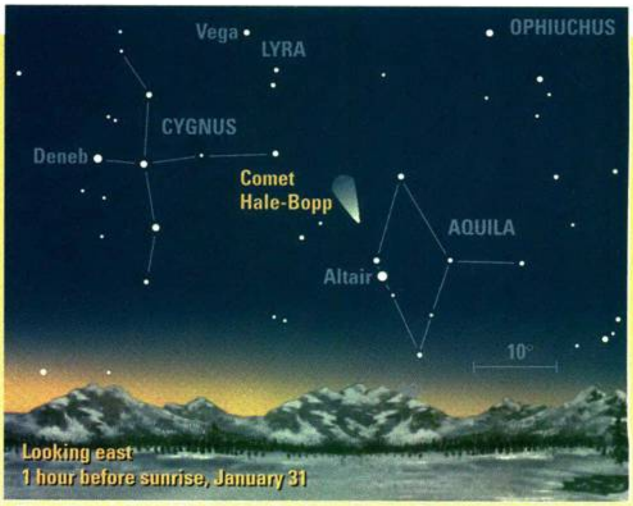
Although it has the same right ascension (the sky's version of longitude) as the Sun, and is therefore in conjunction, our spring showpiece is far enough north to be readily visible in the binoculars of middle-latitude observers.

Remember Comet Hyakutake in mid-April 1996? Hale-Bopp might be just as bright but with a shorter tail. The best time to view it is about an hour before sunrise. Look for it about halfway between Vega and the invisible Sun below the horizon.

The 3rd- to 4th-magnitude comet hangs some 10° above the eastern horizon on January 1, nestled in the faint feather-stars of Aquila the Eagle. Those south of latitude 35° might have a tougher time spotting Hale-Bopp in early January.

For observers in Florida, Hale-Bopp will be a scant 5° above the horizon. Observers above 45°, like Canadians and Europeans, will be luckier and see it 13° into a dark morning sky.

Conditions improve markedly by the end of the month. An hour before sunrise, Hale-Bopp will be 25° above the eastern horizon for the middle latitudes — a bit lower for southerners — and higher still for northerners. — *A. L.*



Observer's Challenge: The Double Bubble

Gemini's best known planetary nebula is without a doubt the Eskimo, NGC 2392. This famous shell of gas from a dying star overshadows another noteworthy planetary called NGC 2371-2. If it weren't for the nearby Eskimo, NGC 2371-2 would be on more of the popular observing lists.

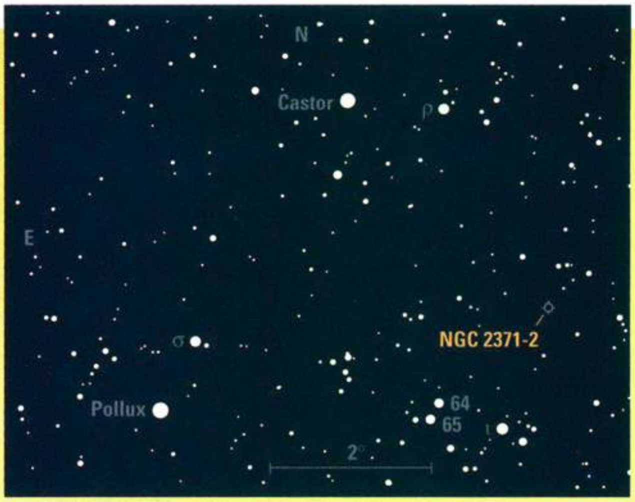
Some call it the Double Bubble because it has a most unusual appearance for a planetary nebula. Two rounded puffs of gas lie side by side, with each lobe getting brighter towards the middle.

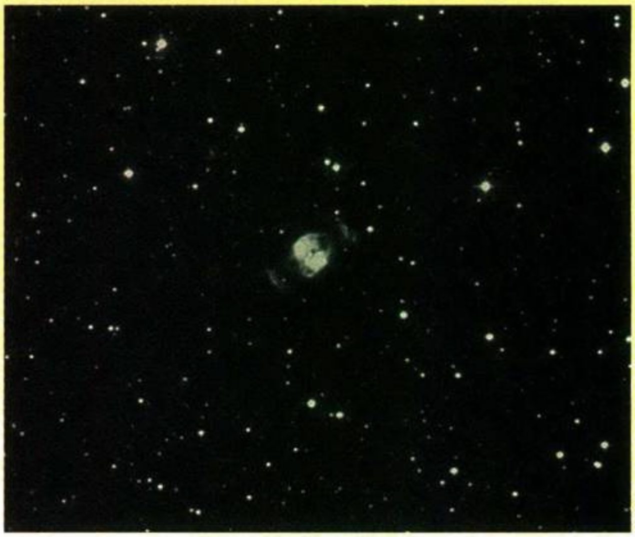
Even discoverer William Herschel was misled by this structure, and did not put it in his "planetary nebula" class of deep-sky objects.

An 8-inch scope under average skies can bag this twin nebula not far from Castor and Pollux. Try starting at the naked-eye star Iota (ι) Geminorum. Then scoot your scope 1.8° north — about two fields of view at low power — to land on the twin-lobed patch of gas.

The Double Bubble is visible at low power because its size, 54" by 35", is almost as big as Lyra's M57, the Ring Nebula. Pump up the power past 200x, if the winter stars aren't twinkling madly, to resolve some detail. Can you tell which lobe is brighter? On a steady night, a 12- to 14-inch telescope will reveal the pinpoint central star responsible for this magnificent cloud.

The intricate structure of the Double Bubble makes it an ideal target for CCD astrophotographers. Will a CCD image reveal NGC 2371-2's subtleties like Hubble has done with the Eta Carinae Nebula? — *A. L.*





STScI

Mars begins the year lying 3° east of 4th-magnitude Beta (β) Virginis, looking like an orange, 1st-magnitude star. New Year's Day sees it 3° north of the last quarter Moon.

Mars gets another visit by the last quarter Moon on January 28, when the Moon glides 3° south of the Red Planet. By that time it's brightened to a respectable –0.2, easily outshining nearby bluish Spica.

Several hours pass until another planet climbs into the night sky. As dawn's light ushers in a new day, blazing **Venus** begins its ascent in the east, joined on January 12 by **Mercury** about 3° to the north.

At magnitude 0.5, Mercury is a lot fainter than Venus' dazzling –3.9, but Venus is heading closer to the Sun while Mercury has yet to reach its greatest elevation above the eastern horizon.

The best chance to view Mercury occurs around January 23/24, when it lies a full 25° from the Sun and shines at magnitude –0.1. That morning the innermost planet rises 90 minutes before the Sun.

Also greeting the sunrise, but much farther from the Sun than Mercury, is **Comet Hale-Bopp**. It reappears in the eastern morning sky by late January, moving through Aquila on its way to an April 1 perihelion appointment with the Sun (see "The Year of the Comet," page 82).

Early risers should have a fine view of this, the opening scene of Hale-Bopp's final act. During the next three months the comet should put on a fine display, becoming an easy naked eye object. If you have a new telescope or pair of binoculars, now is the time to practice using it on this wonderful celestial apparition.

Comets are known to leave debris around their orbits, and if Earth's orbit intersects one of these regions, a meteor shower results. The **Quadrantid meteor shower**, which peaks on January 3, is such a shower. Its parent comet, Comet Machholz, was not discovered until 1986.

Named for the defunct constellation of Quadrans Muralis, the Quadrantids stream from a region between northern Bootes and the Big Dipper.

Up to 100 meteors an hour have been recorded, after the radiant gets higher during the early hours of morning. Start looking about two hours before Venus rises to guarantee spotting the greatest number of meteors. □

Martin Ratcliffe directs the Henry Buhl, Jr. Planetarium in Pittsburgh, Pennsylvania. Alister Ling is a meteorologist for Environment Canada in Alberta.

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2'' O.D. plug	**2/$2**	3½'' O.D. plug	**$1.50**
1¼'', 1⅜''	**3/$2**	7½''	**$10**
1½''	**2/$2**	9½'', 10.4''*	**$15**
2''	**2/$2**	12½'', 12⅞''*	**$20**
2⅛''	**2/$20**	15.0'', 15.6'', 16''*	**$28**
5½''	**$6**	19'' (DS-16)	**$35**
*Fits Odyssey		21'' (Odyssey-II)	**$35**

MEADE 7'' - 16'' LX200
NEW! 7'' - 10'' LX50

8'' LX50
$1395

16'' LX200 $14,950

Meade 8'' LX200 Telescopes

LX50 - includes dec. motor, hand controller.
LX200 - full computer control w/64K obj. mem.
Tripod: extra for LX50; included for LX200

NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your LX200.

NEW! 3.5'' f/14 ETX Maksutov ($20)	**$495**
Meade 2045D 4'' f/10 w/motor ($20 P&S)	**$699**
8'' LX10 w/wedge, hand controller ($65)	**$995**
Field Tripod for 8'' LX10 ($20)	**$195**
8'' LX50 w/wedge ($105 P&S)	**$1395**
Tripod for 8'', 10'' LX50 ($30 P&S)	**$295**
8'' LX200 w/computer ($105 P&S)	**$2795**
Wedge for photographing w/8'' LX200	**$139**
7'' LX50 f/15 Maksutov w/wedge ($125 P&S)	**$1795**
10'' LX50, f/10 w/wedge, dec. motor, hand controller ($145 P&S)	**$1695**
10'' LX200 w/computer ($145 P&S)	**$3195**
12'' LX200 (f/10 only)($215 P&S)	**$4495**
Super Wedge for photogr. w/10'',12'' LX200	**$395**
16'' LX200 f/10 w/tripod ($385 P&S)	**$14,950**

Dew Shields: 8'' .... **$119;** 10'' **$129**
12'' .... **$189;** 16'' **$289**

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4'', 8'', f/6 or f/10	**$249**
Giant EASY-GUIDER for 10''/12'' f/4-f/10	**$395**

MEADE STARFINDERS

8'' f/6
$749

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6'' f/8 Dobsonian Starfinder ($46 P&S)	**$319**
6'' f/8 Equat. Starfinder 6(add $79 P&S)	**$649**
8'' f/6 Dobsonian Starfinder (add $59 P&S)	**$419**
8'' f/6 Equat. Starfinder 8 (add $89 P&S)	**$749**
10'' f/4.5 Dobsonian Starfinder ($85 P&S)	**$599**
10'' f/4.5 Equat. Starfinder 10 (add $99 P&S)	**$879**
12.5'' f/4.8 Dobsonian Starfinder ($95 P&S)	**$895**
16'' f/4.5 Dobsonian Starfinder (freight COD)	**$1195**
16'' f/4.5 Starfinder 16 (ship. freight COD)	**$2695**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

LUMICON Single axis drive corrector	**$99**
Magellan computer; specify Dob. or Eq. ($15 ship)	**$295**
Meade 47M Dual-axis drive corrector with tangent arm & electric declination	**$475**

SKY VECTOR™ $299!!

Includes Computer, Encoders, Hardware

LOW PRICE—from $299

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $299

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $349

10,000 Objects! — Also includes Identify (Sky Tour) Function, planets and full visual descriptions.

NGC SKY VECTOR™ $439

12,000 Objects!— PC Serial Port

NGC-Sky Vector
OFF ON
MODE
ENTER
UP
DOWN
LUMICON

NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16'' Dobsonian.

Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER	**$189.50**
2'' EASY-GUIDER (Mamiya 645)	**$239.50**
2'' Adapter for Pentax 6X7	**$129.00**
2'' Adapter for Hasselblad	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$259.00**

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	**$119.50**
UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$69.50**
LUMICON 2'' Helical Focuser 1½'' high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' **adapter** w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$189.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$69.50**, 45° version	**$69.50**
1¼'' straight-thru 80mm SUPER-FINDER	**$189.50**
1¼'' right-angle 80mm SUPER-FINDER	**$199.50**
1¼'' right-angle version, w/star diagonal	**$239.50**
25mm Cross-hair 1¼'' eyepiece (12X)	**$59.00**
Large mounting rings for 80mm Finder	**$55.00**
1¼'' Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	**$29.50**
2'' adapter for C-80, C-100 refractor	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	**12.00**
2½'' long extension (holds 1¼'' filters)	**19.50**
4½'' long extension for 1¼'' eyepieces	**$29.00**
3'' long extension for 2'' eyepieces*	**$29.00**
2'' long extension for 2'' eyepieces*	**$29.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$25.00**
2''/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

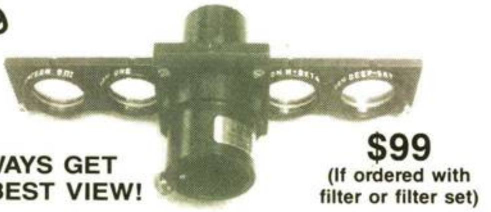
Meade & Celestron
LUMICON carries a full line of telescopes and accessories. Fast Delivery. Competitive Prices.

LUMICON FOR HIGH PERFORMANCE

Visit our LUMICON web-site: http://www.rahul.net/Astro-Mall

NEW LUMICON MULTIPLE FILTER SELECTOR

$129



ALWAYS GET THE BEST VIEW!

$99
(If ordered with filter or filter set)

The New LUMICON Multiple Filter Selector holds up to 5 1¼'' LUMICON filters. The sliding bar has a click-stop at each filter position. Now you can instantly select the best filter for any deep-sky object. Cost is $129 or $185 with 1.5X relay lens (for Newtonians). **Save $30 if ordered with filter(s)!**

TELE VUE™

NEW! Bino Vue Binocular Viewer

Genesis-SDF 4'' f/5.4 apochromat	$1950
Pronto 70mm f/6.4 apochromat w/2'' diagonal	$939
Pronto 70mm f/6.4 w/45° erecting prism	$789
NEW! Bino Vue binocular viewer	$899
Gibraltar mount with ash wood tripod	$495
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$79
8, 11, 15mm Plossl **$89**, 20, 25mm	$99
32mm Plossl, widest true field in 1¼''	$119
55mm 2'' Plossl, widest possible field	$229
2.0x or 3.0x Tele Vue Barlow Lens	$115
2'' Giant Barlow - 2x	$179
15mm Wide-Field, 1¼'' eyepiece, 65°	$139
19mm Wide-Field, 1¼'' eyepiece, 65°	$149
4.8mm Nagler, 82° field, 1¼'' eyepiece	$169
7mm Nagler, 1¼'' eyepiece, 82° field	$219
9mm Nagler, 82° field, 1¼'' or 2''	$239
13mm Nagler, 82° field, 1¼'' or 2''	$299
12mm Nagler, Type II, 82°, 1¼''/2''	$279
16mm Nagler, Type II, 82°, 1¼''/2''	$299
20mm Nagler, Type II, 82°, 2'' only	$375
1¼'' Paracorr Visual Coma Corrector	$159
2'' Paracorr Visual Coma Corrector	$249
15mm Panoptic 1¼'', 68° field	$209
22mm Panoptic 1¼''/2'', 68°	$269
27mm Panoptic 2'', 68° field	$319
35mm Panoptic 2'', 68° field	$349

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3'' & 2.1'' enhanced aluminum diagonal mirrors & 1¼'' star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32''	**$39.50**	1.52''	**$45.00**	1.83''	**$49.50**
2.14''	**$59.50**	2.60''	**$75.00**	3.10''	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼'' (1.32'' mirror)	**$99.50**
2'' (1.83'' mirror)(see photo above)	**$189.50**

LUMICON FILTERS — BEST IN THE WORLD!

''The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain.''
***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

''Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed.'' ***SKY & TELESCOPE*, July 1995**

BETTER THAN A DARK-SKY SITE!?

''From my light polluted backyard, the view .... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site.'' ***SKY & TELESCOPE*, July 1995**

SEE THE HORSEHEAD!

*''**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . .''* ***SKY & TELESCOPE*, July 1995**

''I CAN SEE THE VEIL NEBULA!''

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *''It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters.''*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

''Stunning is all I can say,'' says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*''Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae.''* ***ASTRONOMY*, February 1991**

	Premium*
0.96'' **LUMICON DEEP-SKY Filter** threads into most 0.96'' eyepieces	$59.50
1¼'' **LUMICON DEEP-SKY Filter** threads into most 1¼'' eyepieces	$99.50
48mm LUMICON DEEP-SKY Filter (1.7'' aperture), threads into most 2'' eyepieces. Also fits LUMICON EASY-GUIDERS	$199.50
2'' LUMICON DEEP-SKY Filter (1.5'' aperture), threads into most 2'' eyepieces. Also has male & female camera T-threads for prime focus photography	$199.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)	$399.50
2'' Rear Cell Filter, fits SCT's Deep-Sky, **$199.50** UHC, O-III, H-Beta,	$199.50
1¼'' **LUMICON UHC Filter** threads into most 1¼'' eyepieces	$99.50
48mm LUMICON UHC Filter (1.75'' aperture) fits most 2'' eyepieces	$199.50
Choice of ***any two*** LUMICON filters (**Save 7%**) 1¼'' **$185.00**; 48mm	$370.00
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼'' $99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines 1¼'' **$99.50; 48mm**	$199.50
LUMICON Comet (Swan band) Filter 1¼'' **$99.50; 48mm**	$199.50
Telephoto lens adapter for 2'' or 48mm filter. Select 46, 49, 52, 55, 58mm	$7.95
Universal adapter for 1¼'' filters. Adapts the 1¼'' filters to any 1¼'' eyepiece	$19.50
Universal adapter for 48mm or 2'' filters. Allows use of any 1¼'' eyepiece	$25.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16'' aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6'', 8'', 10'', 11'', 14'', 16''

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	H-Alpha	(DS)
46, 48, 49mm	$59.00	$199.50
52, 55, 58, 62mm	$69.00	$199.50
67, 72, 77mm	$79.00	$399.50
82mm (77mm + adapter)	$89.00	$415.00

Hypered 2415 film, 36 exp . . $11.95, $3/$32

LUMICON®

2111 Research Dr. #5A, Livermore, CA 94550
For phone orders please call (510) 447-9570
FAX (6 PM-9 AM PST) (510) 447-9589
LUMICON Products catalogue FREE
All foreign orders add 8% ($10 minimum)
California residents add 8.25% tax.
Prices subject to change w/o notice.
Hrs: M-F 9 am - 5 pm, Sat. 9 am - 1 pm

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5'' plates and film up to 5X7''. Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2'' or 1¼''.

NEWTONIAN EASY-GUIDER **$189.50**
48mm Coma corrector/field flattener .. **$285**
3X Relay Diagonal (see photo) **$99.50**
Illuminated reticle eyepiece, pulsed . **$109.50**
Guider for Hasselblad **$409,** Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$225,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10-12'' Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$295,** Mamiya 645**$149**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** ... **$109.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.

2. **Cable release** for long exposures . **$9.95**

3. **Declination motor** (state telescope type) **$109**

4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.

5. **LUMICON EASY-GUIDER** (selection to left)

6. **LUMICON 48mm DEEP-SKY FILTER $199.50**
This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.

7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF! HYPERSENSITIZED FILM

TP 135-36
SR1600
Scotch
1000

HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
Kodak PPF-400, THE BEST!	36	**$15.95**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Gold 1000 fast, fine grain	12	**$13.95**
Fuji G800 fine grain color neg.	**24**	**$13.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

Discover the Winter Sky

Your 2- to 6-inch scope can reveal numerous wonders in the Winter Milky Way as well as transport you to the Moon, Mars, and Comet Hale-Bopp.

by Glenn F. Chaple, Jr.

It's winter, and much of North America is covered by a Currier and Ives blanket of snow. Nights are incredibly clear, the stars incredibly bright. Center stage belongs to mighty Orion and his retinue of winter constellations.

To pay respects to the Hunter, you'll need to dress appropriately (and I don't mean tuxedos or formal gowns). Proper winter attire means clothing that protects you from those cold nights. Start with thermal underwear and socks, covered with a layer of loose-fitting clothing, and topped off with a parka or one-piece snow suit. Add insulated boots, mittens, and a hat, and you're ready for the winter sky show.

The Winter Moon

Trivia question: In the classic science fiction movie *2001: A Space Odyssey*, which crater was the site of the lunar base? If you guessed Clavius, you're right. You can explore this gigantic walled plain without having to wait for the year 2001 to board a moonbound spacecraft. Just go outside nine or 10 evenings after new Moon (the Moon's waxing gibbous phase), aim a small telescope moonward, and — voilá — Clavius. Well, it might not be that simple. Clavius is huge (its 225-km diameter would encompass Massachusetts, Connecticut, and Rhode Island), but it tends to get lost in the jumble of craters that litters the Moon's southern hemisphere (the upper half in the inverting field of an astronomical telescope). Check a good Moon map to find it, such as that in *ASTRONOMY Atlas of the Moon* by Antonin Rükl (Kalmbach Books). Once you've located Clavius, switch to high power and look for an interesting arc of craters of descending size that traverses its extensive floor.

Leaving Clavius behind and following the terminator to a point slightly north of the lunar equator, you'll encounter a spectacular solitary crater. This is Copernicus, regarded by many observers as the Moon's *finest crater*. Ninety-three km wide, with 3,760-m-high terraced walls that stand over a floor punctuated by a mass of central peaks, Copernicus is a breathtaking sight. Study it with the highest magnification your scope and sky conditions allow. A splashy ray system, best seen near full Moon, hints at the violent impact that formed this crater perhaps 800 million years ago. Wouldn't you love to have been around to witness that event?

While you're looking at the Moon, you might want to check the magnifying power of your eyepiece and its apparent field of view — the diameter of the circle of sky an eyepiece can grasp. The Moon, with an angular diameter of one-half degree, makes a great measuring stick for estimating an eyepiece's apparent field of view. If the eyepiece field is three Moon diameters across, you're working with a 1½ degree piece of sky. If the Moon just squeezes into the eyepiece field, you're down to one-half degree. And so on. Knowing both the magnifying power and the apparent field-of-view of an eyepiece makes it easier to locate and observe sky objects.

Mars Watch

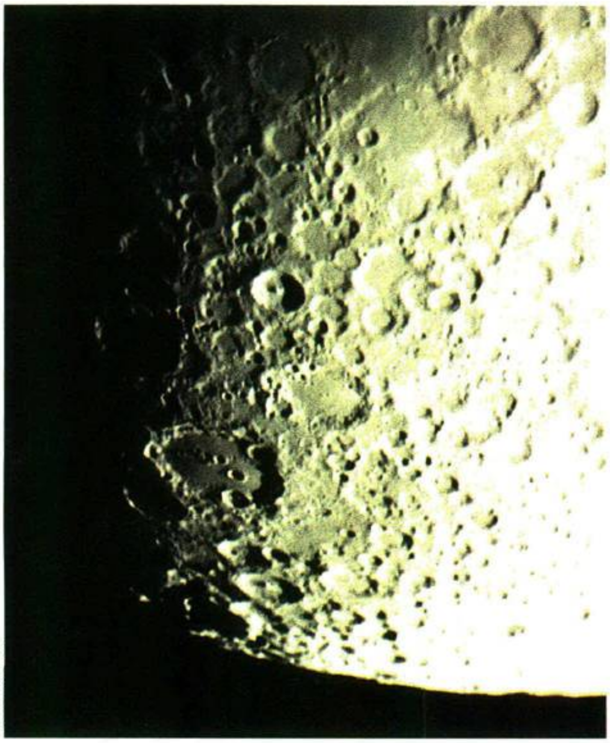
If you're a planet watcher, we have bad news. During the winter of 1996–7, most of the planets will be flirting with the Sun. The major exception is Mars, available in the evening sky several months before and after a March 17 opposition. This won't be a favorable appearance — at best, Mars will be almost 100 million km away. Plan on using magnifications in excess of 100x (see the notes on magnification below). Mars is a tough target for telescopes of any size, but even a small scope can still unveil a surprisingly large amount of the Red Planet's detail. Look for some gray-green markings (highland regions) on Mars' yellow-orange disk, and at least one polar cap shining like a brilliant white bead near the edge of the disk.

When viewing Mars, you'll be tempted to "jack up the power." How much magnification can a telescope deliver while still producing a sharp image? That depends on its aperture (diameter of the light-gathering lens or mirror) and the atmospheric conditions. If the air is steady, you'll get a maximum of about 50x

Tony and Daphne Hallas

per inch of aperture. Under slightly turbulent skies (which, sadly, is the normal state of affairs for much of North America), the highest useful magnification drops to 30x per inch, or about 75x for a 2.4-inch

Orion, crown of the winter sky, rises over the dome of the 42-inch telescope of Lowell Observatory at Anderson Mesa, near Flagstaff, Arizona. Although the 42-inch scope is anything but small, this stunning image of Orion highlights the beauty of winter gazing.


David Fabrizio

Clavius, the large, dish-shaped crater below center, could contain much of New England.

refractor. Don't despair. This is still adequate magnification for most sky objects.

Comet Hale-Bopp

Most of the planets may be playing hide-and-seek, but a long-awaited visit from a junior member of the Sun's family will more than remedy the situation. During February and March Comet Hale-Bopp will be reaching its peak and a small telescope will give you a ringside seat at the event. (See "The Year of the Comet," page 52.) Hale-Bopp may be sporting a tail over 20° long — too long to be completely captured with a telescope. Use low power to "cruise" up and down the comet's length. For a detailed view of the coma, switch to higher magnifications. Above all, enjoy. It may be years before another bright comet visits our skies.

Winter Stars

If stars seem brighter during winter than at other times of the year, there is a reason. They are brighter. Of the 20 brightest stars in the sky, seven are found in and around Orion. Stars are far too distant to be magnified by common telescopes, but the images of 1st-magnitude stars can be dazzling. Check out Rigel in Orion. This superhot giant sparkles white with perhaps a tinge of blue — it's a cosmic diamond. Now try Capella in the constellation Auriga. This time your eyes will be greeted by the golden yellow hue of topaz. Return to Orion, and aim your telescope toward Betelgeuse. This star is ruby red — another heavenly gem. Its image, tossed about by the turbulent night air, almost seems to spit fire.

Have Fun: Get Sirius

Others stars are even more dazzling. But beware observing them when they're low in the sky. Their images will be badly distorted by atmospheric turbulence. Try to view Mars when it's barely above the treetops, and you'll think you're seeing the Red Planet through a quivering bowl of Jello. But sometimes the effects of atmospheric distortion can be downright beautiful. Whenever you see the bright star Sirius flirt-

Buying a Holiday Telescope

With the holiday season at hand, you may be considering the purchase of a small telescope as a gift for someone special. How can you be sure you'll find a quality instrument that will pave the way to a lifetime of astronomy adventure?

For starters, avoid those cheap telescopes that often fill the shelves of department stores. If a telescope sells for under $100, it probably has inferior optics and a rickety mount — guaranteed frustration to a budding astronomer. Look for a store that specializes in optical goods (stores that sell telescopes exclusively are pretty rare, but some camera shops sell binoculars and telescopes). I recommend a 60 to 75mm (2.4- to 3-inch) refractor or a 75mm to 100mm (3- to 4-inch) reflector, mounted on an equatorial mount. Your price tag will be between $150 and $400.

If you can't find anything locally, check out the ads in this magazine. Several reputable companies sell high-quality small scopes. The drawback to mail ordering is the time it takes for a company to process your order and ship it out. Sometimes there are backlogs on popular models, and your selection might not arrive for months after the holidays. To be safe, call the company ahead of time and ask for a realistic delivery date.

Limited by budget restraints? Buy used. Telescopes don't depreciate like automobiles do. If properly cared for, a telescope will work like new for many years. Finding a telescope at local yard sales and flea markets will be a hit- or-miss proposition. You'll fare better at the swap table of a local astronomy convention, or by contacting a nearby astronomy club or planetarium. Some camera shops also sell used telescopes.

It's also possible to order a used telescope through the mail. One source of ads for second-hand astronomical equipment is the Internet. Another is the extremely comprehensive monthly publication *Starry Messenger*. For a sample copy (free, if you mention this article), call (607) 277-6836 or (201) 992-6865 or write to the *Starry Messenger*, P. O. Box 6552–A, Ithaca, NY 14851.

Peter Ledlie

Comet Hale-Bopp (arrow), seen here last July as it slinked through the summer Milky Way, will blossom over the next few months.

ing with the horizon, check it out with your telescope. Atmospheric turbulence has a prismatic effect on the light from this pure-white star. The image flashes with a rainbow of colors — a cosmic kaleidoscope.

The winter skies abound with double and multiple stars that are easily resolved in modest-sized telescopes. One of the best is Castor, the second brightest star in Gemini. Until a decade or two ago, this magnitude 2.0 and 2.9 binary was a bit too close for small scopes. The two are now 3.6" apart — a gap that can be easily breached with 75x to 100x. The sight of these bright side-by-side cosmic gems is so captivating that you may fail to notice a 9th-magnitude star some 73" away. It's a physical member of the Castor system, orbiting the main pair perhaps once every 100 centuries. And there's more. Spectroscopic evidence shows that each of the three visible members of this telescopic triple is itself a close binary pair. When you gaze upward at Castor, you're actually looking at six stars.

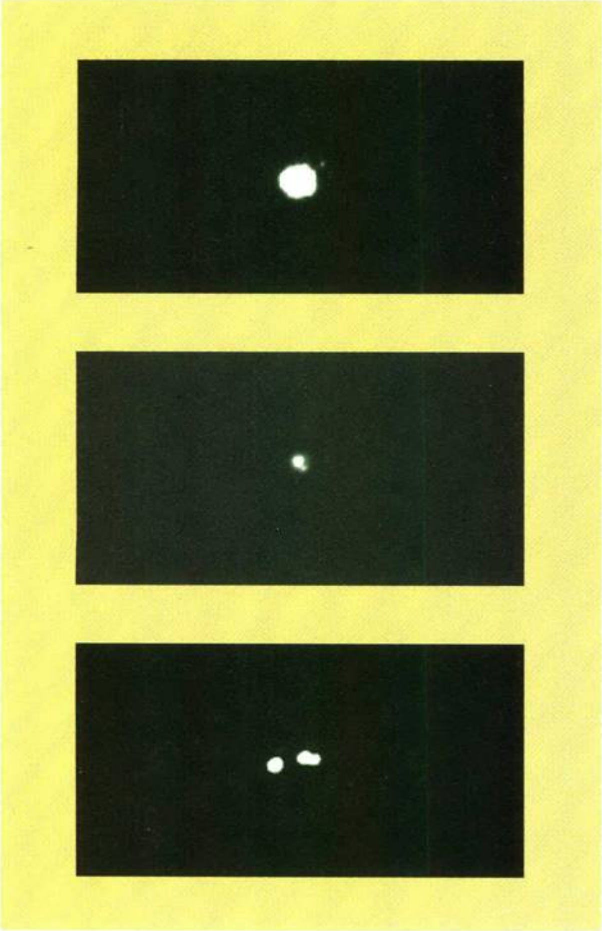
About 12° east and slightly south of Orion's belt is Beta (β) Monocerotis, a triple star first seen by the legendary astronomer William Herschel in 1781, the same year he discovered Uranus. Casually viewed with a

Bob Sandy

Orion's majestic form shrouds a rich hunting ground for small telescope observers. Not only is the brilliant Orion Nebula there, but a bevy of small star clusters and faint planetary nebulae.

Ed Barnes

Gemini's box-like form holds bright, sparkling stars, like Castor and Pollux, some of which are doubles, and a sprinkling of deep-space objects like clusters and nebulae.



John Sanford (all)

A trio of double or multiple stars for small telescopes includes, t. to b., Rigel, Castor, and Beta Monocerotis.

Tony and Daphne Hallas

The core of the Orion Nebula, as viewed in a telescope, consists of a bright matrix of nebulosity with the multiple star Theta^1 Orionis embedded in the center.

small telescope and medium power, Beta Mon looks like an attractive pair of 4th-magnitude stars, separated by about 8". But magnifications of 75x or more separate one of the stars into a pair 3" across. The trio, all of 4th- or 5th-magnitude and enclosed in an area just 10" across, is a sight to behold.

After viewing Castor and Beta Mon, you might be convinced that a double or multiple star has to be bright and close to be visually appealing. Not so. With low power, scan the area immediately south of Betelgeuse. You should find the faint and little-known pair Struve 817.

F. G. W. Struve was an early 19th-century Russian astronomer whose systematic double and multiple star survey resulted in a catalog of more than 3,000 entries. The 817th is a pair of 8th-magnitude stars separated by 18". Not as flashy as Castor or Beta Monocerotis, S817 possesses a uniquely subtle beauty.Check this one out, though, and you'll appreciate it.

George Greaney

Most brilliant and beautiful of all winter clusters is the Pleiades in Taurus, a dipper-shaped group visible to the naked eye. Binoculars reveal a sparkling area of bright stars peppered with a faint spray of tiny white and blue suns. Small telescopes make it a rich kaleidoscope of bright and faint stars — eyeing the bluish dust surrounding them requires a much larger scope.

Winter Deep-Space

What is the finest deep-space object in the entire night sky? A top vote-getter would have to be M42, the Orion Nebula. Visible to the unaided eye as a misty patch of light in the sword of Orion, the Orion Nebula is an awe-inspiring sight in even the smallest telescope. Just be sure to use low power (the Orion Nebula spans one full degree), and observe with dark-adapted eyes on a clear, moonless night. The Orion Nebula is one of the wonders of the heavens — a beautiful gas cloud surrounding and illuminated by the stars it has spawned. Noteworthy among the nebula's infant stars is the beautiful multiple system Theta^1 (θ^1) Orionis. Under magnifications of 60x or more, Theta^1 appears as four 6th- and 8th-magnitude stars, arranged like a tiny baseball diamond just 20" across. Nicknamed the "Trapezium," Theta^1 is perhaps the finest multiple star in the night sky.

In a million years or so, the Orion Nebula will be no more. Gases that haven't condensed into new stars will have been expelled into deep space by the stars' radiant energy. The Orion Nebula will have evolved into the Orion Star Cluster. What will it look like? You can get a rough idea by checking out the open cluster M45 in Taurus. Known more commonly as the Seven Sisters, or Pleiades, M45 is a stunning naked-eye sight. The view is even more impressive in binoculars or a small telescope, which adds dozens of Pleiads to the half dozen or so that the naked eye can see. In fact, this large cluster is most beautiful when viewed in the wide field of a small telescope.

Together, the Orion Nebula and the Pleiades represent the essence of star birth. But the night sky is littered with the graves of stars that have died. One of the most interesting is M1, the Crab Nebula in Taurus. This gas cloud marks the remains of a star whose violent death as a supernova was witnessed by the Chinese in the year 1054. The Crab is conveniently located 1° from Zeta (ζ) Tauri, but don't expect the search to be easy. At 9th-magnitude, the Crab is a rather faint elongated smudge when viewed with small telescopes. Dark skies and dark-adapted eyes are essential. Don't be afraid to use high powers with the Crab: its high surface brightness makes this possible. Observe this ghostly gas cloud on a dark winter night. When a chill breeze ruffles bare branches, you'll really have the feeling of being in a graveyard. ☐

Glenn F. Chaple, Jr. is a teacher living in Townsend, Massachusetts. A frequent contributor, he authored the lead article in ASTRONOMY's Exploring the Universe 1997.

Suit up for Winter Observing

A few simple measures let you venture out under the winter stars in complete comfort no matter what the temperature.

by John Shibley

Outside a frosted window, the winter Milky Way cascades overhead with its icy-bright stars, glistening open clusters, and splashy, glowing gas clouds. Inside, where summer still prevails, you recline on the couch, television remote in hand, muttering "If only it were warmer outside." Not far away, a trusty telescope lies hibernating in a snug closet like a slumbering bear. The furnace's reassuring sound kicks in, but it hardly offsets the periodic pangs of guilt you feel. Another gloriously clear night wasted.

Indeed, winter reduces even the most avid skywatchers to wintertime door-stoop astronomers who glance quickly at a crescent Moon or an occasional grouping of planets. But it doesn't have to be that way. A moderate amount of effort and cold-weather savvy can eliminate what stands between you — specifically the cold weather — and an enjoyable evening under winter's brilliant skies.

Think Layers

First of all, dump the guilt. Eons of evolution have dictated that almost all living creatures should consider warmth a good thing. Accordingly, your instincts — every fiber in your being — say to forget star clusters until spring. But here's where it pays to be a sentient being. You know how to take the warmth with you under the stars. The source: your body; the means: layers of trapped air.

That's what the army concluded after spending (it's rumored) millions of dollars on how to dress for cold weather. It's not necessarily the material that traps heat, but layers of still air. Hence the secret to winter warmth is to insulate with air. Dead air forms a buffer between your heat-releasing skin and the cold, clear night that seeks to suck every joule of infrared energy out of your body.

The best way to accumulate dead air is to create pockets of it. Dress in several layers to create at least three inches of insulation (again, the army study) between you and the night. And make sure these layers are loose, so blood circulation won't get cut off.

Torso and Brain First

Pay particular attention to your body's torso. That's where most of the vital organs reside. An evolutionary trip-wire shunts blood away from your extremities (like fingers and toes, followed by arms and legs) toward the torso's organs if it senses things are getting too nippy.

Cover it with a T-shirt, then layer on a turtleneck, a heavy wool sweater (that alone has thousands of air pockets), topped by a winter jacket with fiber-fill insulation.

Aside from protecting what's inside the torso, this autonomic reflex kicks in for another vital organ. If the brain's heat loss becomes extreme, blood vessels in the toes and fingers constrict so the brain gets more blood. In extreme instances, this reflex will even sacrifice limbs to the ravages of frostbite.

Long before that happens, though, your toes and fingers will feel cold and clammy. So the secret to keeping your extremities warm lies in literally keeping a lid on heat loss through the head. Keep it covered, which means the top, cheeks, ears . . . whatever can hand off heat. This is where a balaclava comes in handy. If your winter jacket has a hood, all the better.

They Aren't Expendable

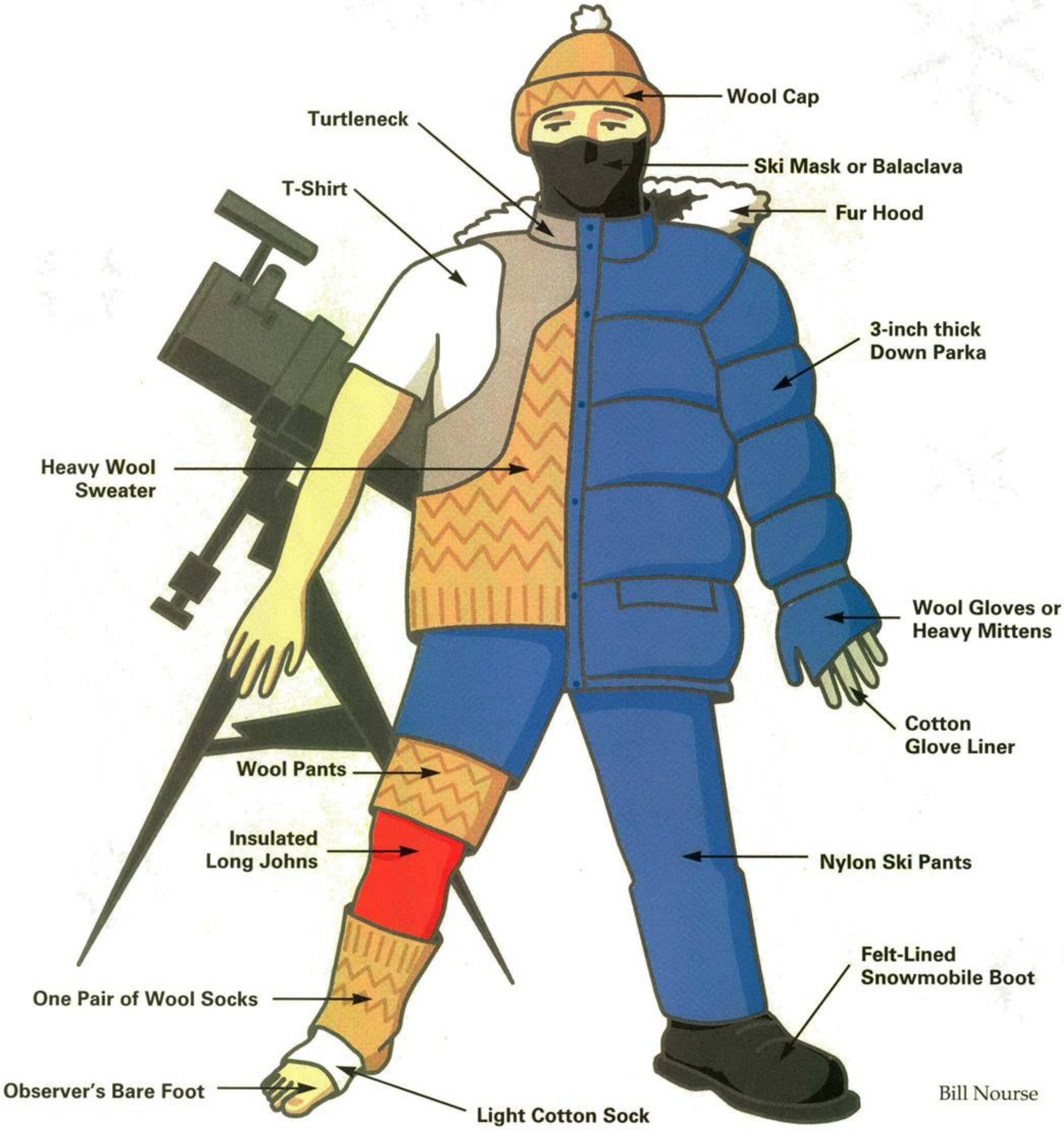
But let's not assess the brain and other internal organs complete blame if your fingers and toes get uncomfortable. Your digits themselves surrender heat. Again, the secret to keeping them warm lies in layers.

For the fingers, start with cotton (which draws perspiration away from the skin) glove liners topped by wool mittens. Such liners assure a certain measure of dexterity if you must doff the mitts to insert an eyepiece into the telescope.

You won't need such flexibility when it comes to your feet, unless you insert eyepieces in unorthodox ways. Slip feet into light cotton socks covered by wool socks, all inside oversized snowmobile boots lined with felt. Some grizzled winter observers advise going with a boot one size larger to accommodate still more layers of socks. Again, don't pack things too tightly; many a skywatcher has suffered clammy feet brought on by a lack of blood circulation.

Finally, one big area of real estate lies between feet and torso. Cover your legs in long underwear, heavy wool pants, and a thin nylon wind shell for durability when kneeling on the ground. A waterproof wind shell might be useful, in case it's damp and cold.

The Properly Attired Winter Observer


Wool Cap
Turtleneck
Ski Mask or Balaclava
T-Shirt
Fur Hood
3-inch thick Down Parka
Heavy Wool Sweater
Wool Gloves or Heavy Mittens
Cotton Glove Liner
Wool Pants
Insulated Long Johns
Nylon Ski Pants
Felt-Lined Snowmobile Boot
One Pair of Wool Socks
Observer's Bare Foot
Light Cotton Sock

Bill Nourse

Embrace Low-Tech

One word from the wise: Be wary of "high-tech" garments that promise warmth at any temperature. So-called winter activity wear assumes you'll be doing a fair amount of heavy activity like skiing or snowshoeing. In reality, observing entails long periods of inactivity, save for the occasional elevated heartbeat when the Orion Nebula drifts through an eyepiece's field of view. For the observer's purpose, cotton to absorb perspiration and wool to trap body heat does just fine.

With this air of simplicity in mind, suit up like a medieval knight and awake your slumbering scope for a ride under the stars. Wrapped in layers of wool and cotton, you'll be protected within a climatic cocoon of spring-like temperatures. Enjoy yourself, for in a few months summer returns with a vengeance to quash that primal urge to stay close to heating vents. □

Associate editor John Shibley cut his teeth on wintertime observing in Michigan's Upper Peninsula.

Whether you want to capture an image of Hale-Bopp or just

The Year of the Comet

By Don Machholz, Glenn Gombert, and Joe Tarkeney

Memories of Comet Hyakutake's brilliant appearance last spring still burn brightly in the minds of backyard observers. The brightest comet since West 20 years before, Hyakutake awed veterans and newcomers alike with delicate streamers of gas and dust flowing into a tail that seemingly spanned half the sky.

As great as Hyakutake was, however, it may have to take a back seat to 1997's Comet Hale-Bopp. This spring the long-awaited comet could surpass Hyakutake as the brightest comet of the past two decades and create a fresh set of indelible memories for observers around the globe.

As 1997 opens, Hale-Bopp appears in both the evening and morning skies. Unfortunately, at both times it lies low in the twilight sky. (The farther north you live, the higher it appears.) The Moon reaches last quarter phase on the night of January 1/2, casting its unwanted glow in the morning sky, so viewing will be best in the evening. At a site far removed from city lights, the comet should show a coma nearly ½° in diameter and a tail stretching perhaps 10°.

As January drags on, Hale-Bopp sinks from view in the evening sky but becomes better placed in the morning. With full Moon arriving on January 23, one of the last good views under a dark sky should come around the 20th. By then the comet lies nearly 50 million kilometers closer to us than at the start of the month and should glow around 3rd magnitude.

Comet Hale-Bopp (at left) glided southeast of the bright open cluster NGC 6649 this past July. The comet will skirt near several other impressive deep-sky objects over the next few months.

Bill and Sally Fletcher

view the dazzling apparition, now's the time to get ready.

David Healy

Hale-Bopp sported a short, fan-shaped tail last April. Although predicting a comet's brightness or tail length is uncertain at best, this comet could reach magnitude 0 and have a 10° or longer tail.

In February, Hale-Bopp is an easy target a couple hours before the Sun rises. New Moon comes on the 7th, yielding unhampered comet viewing during the second and third weeks of the month. During this period, the comet travels through the rich Milky Way starfields of Sagitta and Vulpecula, skimming ½° from the globular cluster M71 on the morning of the 7th and 3° from the Dumbbell Nebula (M27) on the 10th and 11th. Both conjunctions should provide excellent photo opportunities.

Luck is on our side through much of March because the comet can be seen both in the northwest after sunset and in the northeast before sunrise. But the trend is definitely toward better evening viewing, with Hale-Bopp growing brighter and climbing higher in the sky. Unfortunately, the Moon also grows brighter in the evening during the middle of the month, until it reaches full phase on March 23/24.

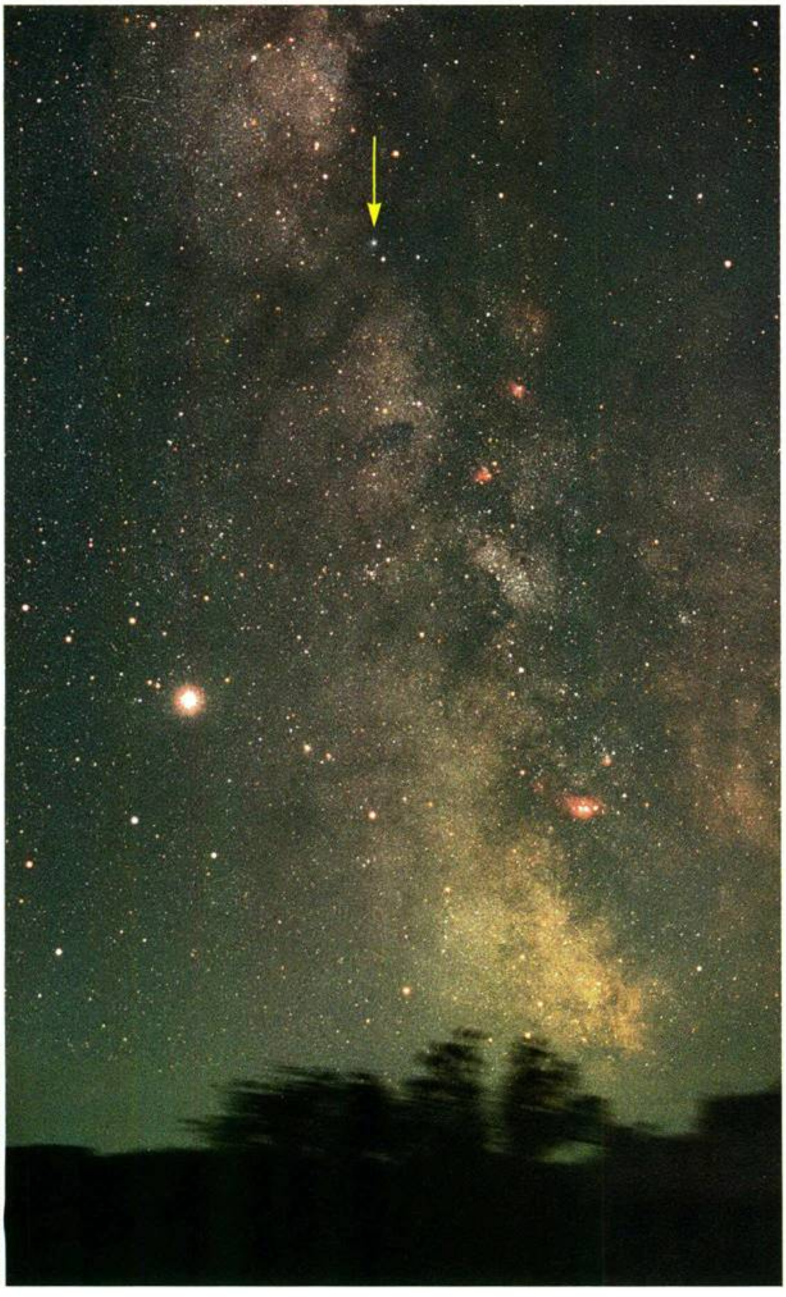
The light of the full Moon doesn't totally wash out the comet, however, at least for the whole night. In a coincidence of cosmic proportions, the Moon passes through Earth's shadow! This deep partial eclipse — at maximum 92% of the Moon lies in the shadow — allows the comet to shine in nearly all its glory despite the full Moon. Maximum eclipse comes at 11:39 p.m. EST (10:39 p.m. CST, 9:39 p.m. MST, and 8:39 p.m. PST), placing the comet in the sky with the eclipsed Moon for observers in western North America.

The next week to 10 days should be the most spectacular of Hale-Bopp's visit. The comet should peak in brightness, perhaps reaching magnitude 0, and rival the brighter stars in the sky. Its brightness now stems from its close approach to both Earth and the Sun: On March 22 it passes within about 200 million km of Earth (compared with 15 million km for Hyakutake at its closest) and on April 1 it comes within 140 million km of the Sun.

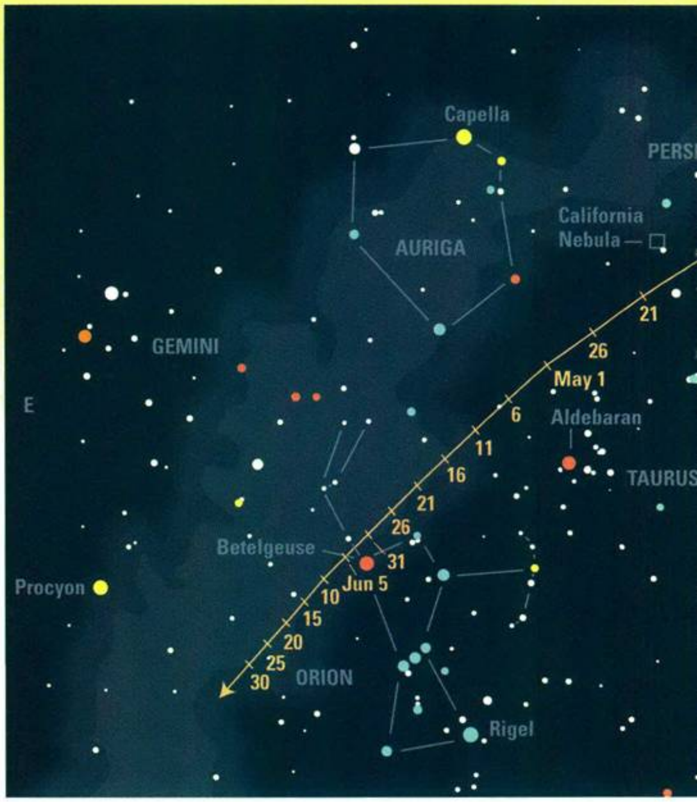
The highlight of this period comes between March 23 and 25, when Hale-Bopp passes less than 5° north of the Andromeda Galaxy (M31), the nearest large galaxy to our own. In late March, view the comet in early evening when it appears higher in a dark sky (setting more than two hours after twilight ends) and doesn't have to compete with the Moon's glare. For those who want to show Hale-Bopp to the public, the final weekend of March should also be a good time — the comet is bright, the Moon is out of the way, and the media should be covering the story.

Hale-Bopp remains reasonably high in the evening sky throughout April as it passes through Andromeda and Perseus. But the Moon interferes with observing from mid-April until a few nights after it's full on the 22nd. By May 1 the comet has moved into Taurus and appears both noticeably fainter and closer to the horizon after sunset than it did a month before. Just two weeks later, the comet sets with the western sky still awash in twilight, and most Northern Hemisphere observers will have had their last good view.

The summer Milky Way forms a stunning backdrop for Comet Hale-Bopp (arrow) and brilliant Jupiter. Capturing vistas like this requires a camera piggybacked on a telescope tracking the stars.



Gerald Rhemann and Franz Kersche



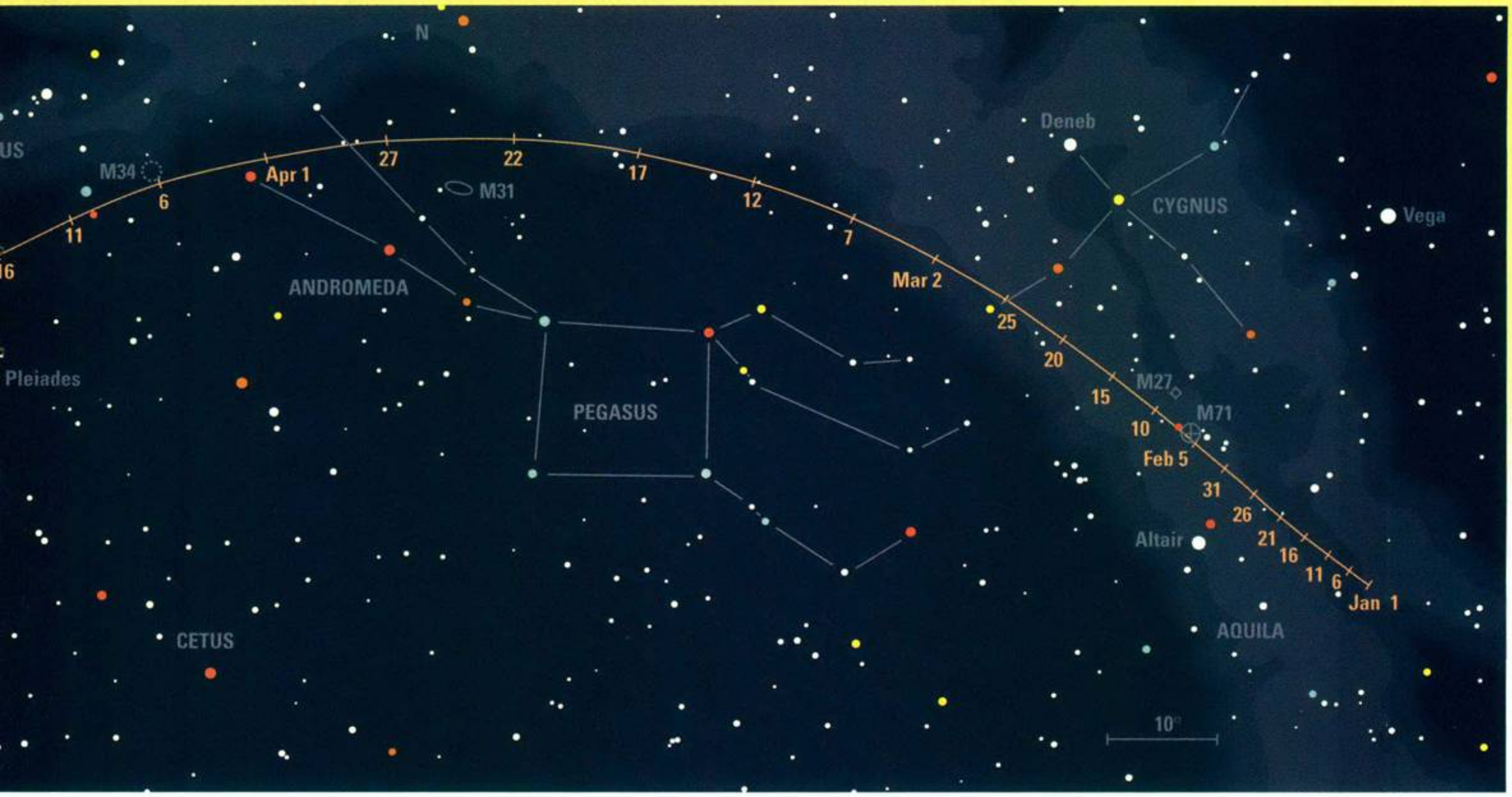
For many people, simply viewing a beautiful comet is enough. For others, the experience isn't complete without capturing an image that they can look at again and again. Fortunately, anyone with a 35mm camera capable of taking time exposures can record a stunning image of Comet Hale-Bopp.

The simplest technique calls for placing your camera on a tripod, loading it with fast film, and picking a lens that will capture the entire comet. The focal length of the lens you choose determines how much sky you'll record. If Hale-Bopp develops a 10°-long tail (the angular size of a closed fist held at arm's length), a 200mm telephoto lens will just capture it.

Of course, you don't have to fill the frame with the comet — many great shots show a comet riding majestically above a pretty horizon scene. A typical 50mm lens will capture 40° of sky, which should be plenty to record Hale-Bopp along with a stunning foreground.

Camera-on-tripod photography requires short exposures so that star images don't trail. That's the purpose of using fast film: to keep exposures short. Don't be afraid to go with 1000-speed film or faster. With the lens wide open, focus on infinity and try exposures of roughly 2 to 5 seconds with a 200mm lens or 15 to 25 seconds with a 50mm lens. And bracket your shots by taking photos with exposures ranging from about ¼ to 4 times those recommended.

A second, more complicated technique calls for "piggybacking" a camera on a telescope that can track the stars. Piggyback astrophotography minimizes the trailing of stars, so exposures can be longer and films can be slower with finer grain. Choose a lens with a focal length that encompasses both the comet and the starfield you want to record. This method should produce great results with Hale-Bopp, allowing you to



ASTRONOMY: Elisabeth Rowan

capture the comet as it climbs along the spine of the Milky Way or as it passes near the Andromeda Galaxy.

It takes practice to get good piggyback astrophotos, so if you want to capture Hale-Bopp this way, start experimenting early in the year. (For complete details on this technique, see "Give Your Camera a Piggyback Ride," January 1992.)

For closeup portraits of the comet, let a telescope act as the camera's lens. To make this technique work, you need to precisely polar align the scope and accurately track on the stars. (Get all the details on through-the-scope astrophotography in "Taking Pictures with Your Telescope," December 1992.)

Traditional astrophotographers aren't the only ones who'll try to capture Hale-Bopp this year — astroimagers also will attempt to record the comet with their CCD cameras. One method that works well overcomes the problem of blurry images that arises from guiding on a fixed star when the comet moves relative to the background stars (see "Catching Comets with a CCD," February 1995).

The trick is to freeze the comet as it traverses the sky by using the track-and-accumulate mode of the SBIG ST-6 CCD camera to track the comet's coma. The track-and-accumulate mode was developed to compensate for inaccuracies in a telescope's drive system, such as periodic error, that would normally smear out an image if integrated for a long time. Getting high-resolution color images of comets turns out to be a matter of simply taking a long series of very short exposures of the comet and then combining the individual frames while registering on the comet's core.

For some dedicated observers, Hale-Bopp's apparition promises more than spectacular views and pretty pictures. They will be helping collect comet observations for NASA's Ulysses Comet Watch Program. Launched in 1990, the Ulysses spacecraft was sent out of the plane of the ecliptic (the plane defined by Earth's orbit around the Sun) to study properties of the Sun at high solar latitudes. Ulysses scientists are interested in collecting information on comet ion tails to better calibrate the onboard instrumentation on the spacecraft. Coordinated by Carolyn Peterson and John Brandt at the Laboratory of Atmospheric and Space Physics at the University of Colorado, the Ulysses Comet Watch seeks comet images that can be correlated with spacecraft measurements of the solar wind.

More than 200 amateur and professional observers from 28 countries have volunteered to participate in the comet watch. And this spring Hale-Bopp will be within 20° to 30° of the Ulysses spacecraft's latitude, ideally located for such observations. An FTP site has been set up to receive images from observers around the world. For more information on becoming involved with this project, see the Ulysses project WEB page at http://ulysses.jpl.nasa.gov.

There's no right or wrong way to experience Comet Hale-Bopp. Those who contribute to the Ulysses Comet Watch are no better off than those who try to photograph or image the comet, or those who simply catch a fleeting but satisfying glimpse of the cosmic visitor. The key is simply to enjoy it on your own terms, because no one knows when the next great comet may grace our skies. □

Don Machholz is a noted comet hunter, with nine comets to his credit. Glenn Gombert and Joe Tarkeney are members of the Miami Valley (Ohio) Astronomical Society.

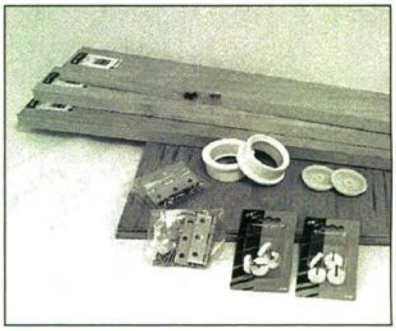
How to Redeem a Department-Store Telescope

You don't need to be a workshop wizard to save the wobbly, little refracter that doesn't satisfy. Turn it into a user-friendly telescope that offers many hours of pleasure.

by David Trott

Are you the disenchanted owner of a "department-store" telescope? The scope's traits are easy to recognize. It advertises high power (400x or more) and stands on wobbly wooden legs. This ubiquitous telescope sells under many brand names for $80 to $150 in department stores, camera shops, and even "educational" toy stores.

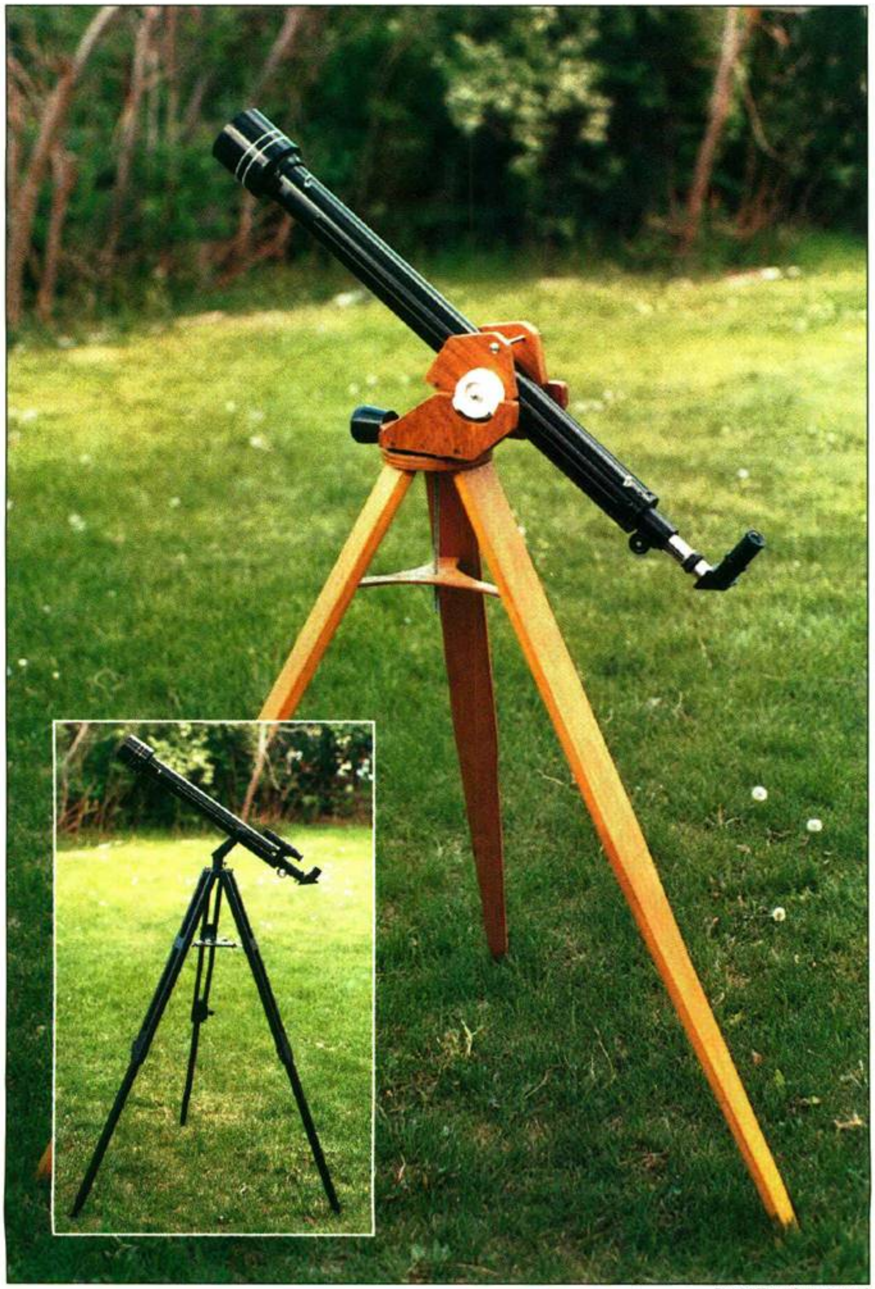
Unfortunately, this type of telescope has notorious deficiencies. The scope usually comes with low quality eyepieces and an inferior finder scope. But fixing the most serious problem — the mount — will go a long way toward improving it.



Carefully read the article, then assemble all materials needed for the project.

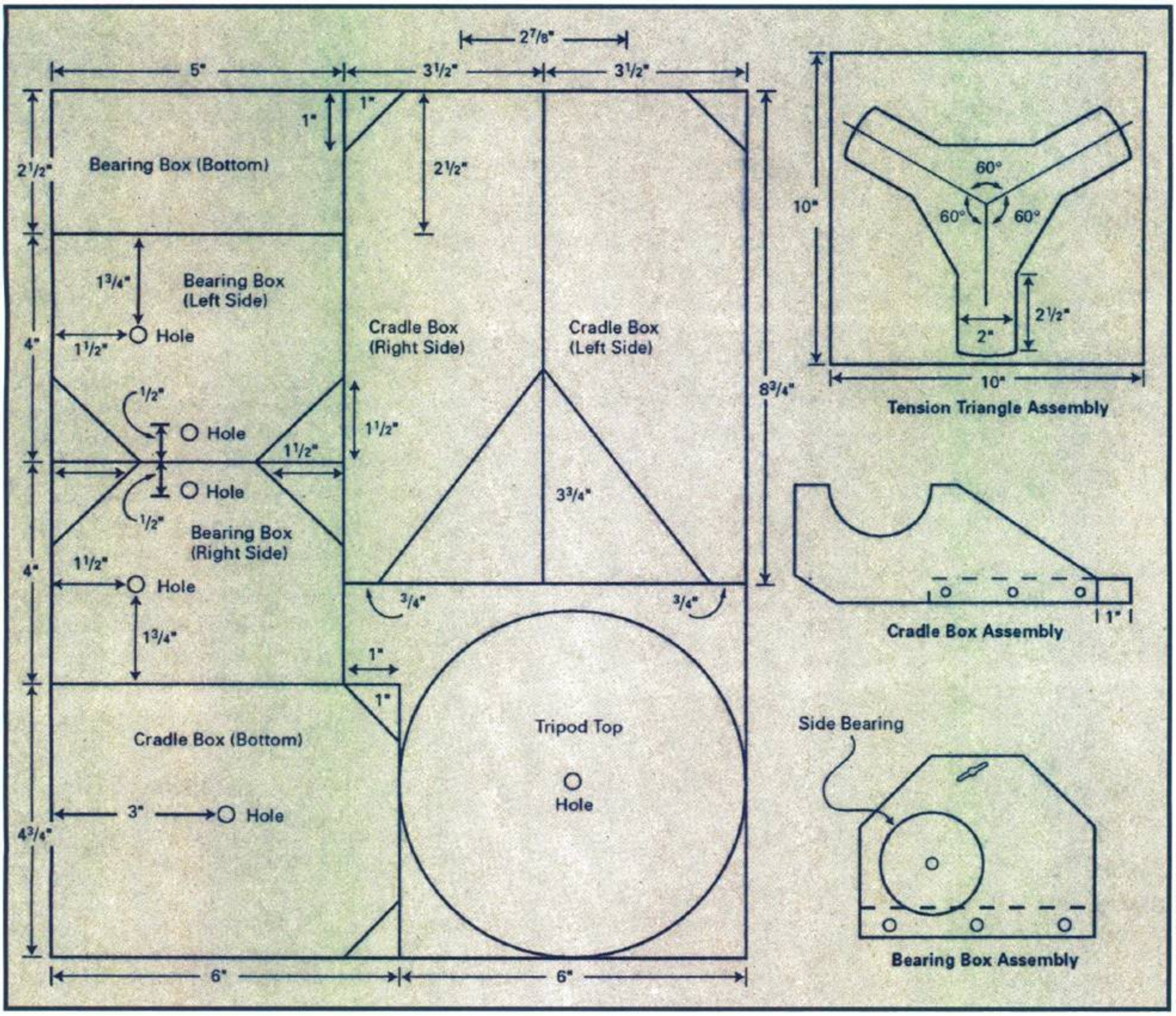
Solutions

You can build an improved, stable mount for a department-store telescope for under $50. The legs on this mount uses one-piece construction, and they are sturdier than the originals. Also, the bearing surfaces are larger to improve stability. Instead of fumbling in the dark to set up the flimsy mount, simply spread the legs and twist the tension triangle into position. The triangle operates smoothly



David Trott (all photos)

Sturdier, more efficient and stable, the new mount will help provide more observing enjoyment. The inset shows the department-store scope before changes.


2⁷/₈"
5"
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Bearing Box (Bottom)
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Bearing Box (Left Side)
4"
1¹/₂"
Hole
Cradle Box (Right Side)
Cradle Box (Left Side)
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Hole
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Hole
¹/₂"
Bearing Box (Right Side)
3³/₄"
4"
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Hole
³/₄"
³/₄"
1³/₄"
1"
1"
Cradle Box (Bottom)
Tripod Top
3"
Hole
Hole
4³/₄"
6"
6"
8³/₄"
10"
60°
60°
60°
2"
2¹/₂"
10"
Tension Triangle Assembly
Cradle Box Assembly
1"
Side Bearing
Bearing Box Assembly

ASTRONOMY: Phil Kirchmeier

and holds the scope in position when released. You track astronomical targets with a simple push of a finger — no knobs to release, no quivers.

The plans above show dimensions for a 2½" telescope. If your telescope has a larger tube, scale up the dimensions; if the tube is smaller, shim the bearing box to make it fit.

Construction Steps

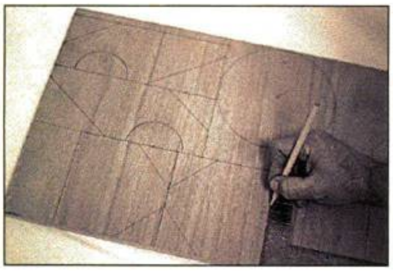
Obtain all materials and prepare to cut the wood.

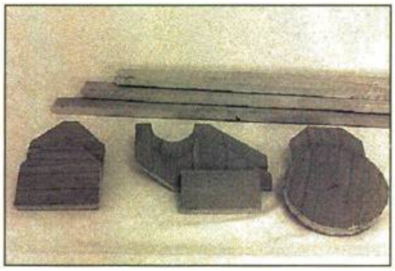
Carefully lay out the plans directly on the ¾" plywood. If your side-bearings (PVC plumbing fittings) are not quite 2⅜" diameter, carefully measure their diameter and add the thickness of the foot pad bearings to calculate the radius of the semicircular cut in the cradle sides. Before you make any cuts, be sure the bottom piece of the bearing box is the same width (2½") as your telescope tube. If not, you will have to adjust some of the measurements appropriately. When everything is correct, make your cuts. Use a special fine-toothed blade. Cut the 10" by 10" piece of plywood to make the tension triangle.

Use a wood filler to fill any gaps in the plywood and give all pieces a preliminary sanding. Be sure to sand the "points" of the tension triangle and round them off a bit. Later, some touch-up sanding might be necessary to finish construction.

Assemble

The offset position of the side bearings is necessary to provide clearance for full motion and

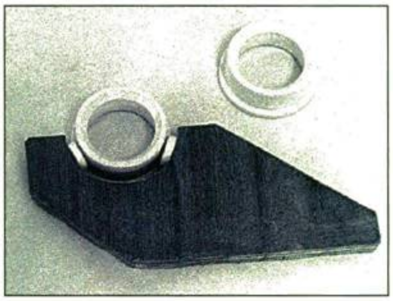




Transfer the plans from the blueprint to the plywood, then make cuts using a fine-toothed blade. The photo at right shows cut pieces for the new mount minus the tension triangle.

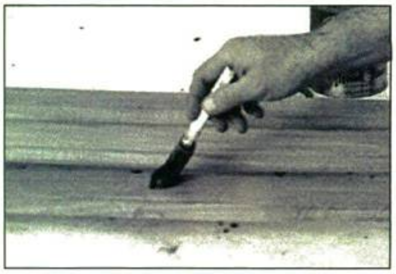
proper balance of the assembled telescope. Drill ¼" holes at the indicated positions. On the inside of each of the sides of the bearing box, drill a countersink for the ¼" tapered head bolts attaching the side bearings. Make sure the countersink is deep enough so the heads of the bolts will not protrude into the space for the telescope tube.

Use screws and wood glue to attach wood to wood for sturdiness and durability. Start by assembling the bearing box, which actually holds the telescope tube. Be sure the holes for the screws are pre-drilled and the inside dimension of the bearing box is the same width as your telescope tube. Next, attach the side pieces to the base of the bearing box. Drill the two ¼" holes at the top of the bearing box. These holes are for the tension bolt which squeezes the telescope tube to hold it securely in the bearing box.



Use a fine drill bit (1/16" to 5/32") to pre-drill foot pad holes, and fit them as shown.

After assembling the bearing box, begin the cradle. Before you actually put the cradle together, check to make sure the sidebearings (the two pieces of round PVC plumbing fittings) fit well in the semicircular cuts with the foot pads inserted. If they do not, you may have to re-cut the semicircles. The foot pads can be shimmed with small washers, if necessary. The sidebearings should rest cleanly on the foot pad bearings without touching any other part of the cradle box. The bearing box should move freely up and down within the cradle. Be sure the telescope tube can swing to a full vertical position, then attach the sides of the cradle box.



In a well-ventilated workspace, paint or finish with your product of choice.

Paint or finish

Follow the directions on the label of the paint or finishing product you have selected, and allow adequate drying time before continuing.

Final Assembly

Attach the side bearings to the bearing box. The nuts should be tight so that the side bearings do not rotate on the bolt. Line the inside of the bearing box with felt so that only felt makes contact with the inserted telescope tube. Test the assembly for fit with the telescope tube inserted. It should be snug but not binding. Install the 4" bolt in the top of the bearing box with a washer and wing nut. The telescope tube should slide forward and backward easily when the wing nut is loose and stay firmly in place when the wing nut is tightened. Tighten the wing nut enough so that the tube is firmly in place. Verify that the outside walls of the side-bearing box are parallel.

Trace the bottom bearing circle onto the Formica, cut it about ⅛" inside the circle, then attach it with contact adhesive. Drill a ¼" hole in the center. Lay out the three hinges, which will attach the legs

Use the bottom bearing plate as a template to mark and cut the linoleum or Formica.™

Materials for a Beefed-Up Mount

The materials needed to build this mount are available at your local home improvement store.

Wood:

3 1" x 3" x 4' pieces of a hardwood for legs (as stiff as possible)
1 12" x 16" piece of ¾" plywood
1 10" x 10" scrap of plywood, any thickness from ¼" to ¾"

PVC plumbing fittings

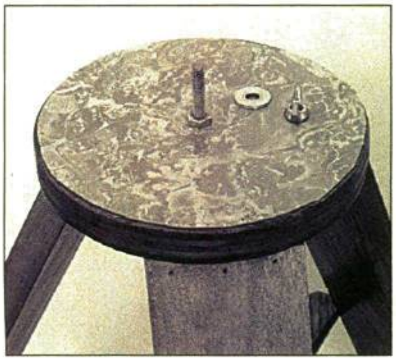
2 Reduction fittings (2 to 1½" PVC pipe reducer fitting)
2 End caps (1½" plastic, snug fit to reduction fittings)

Finishing material

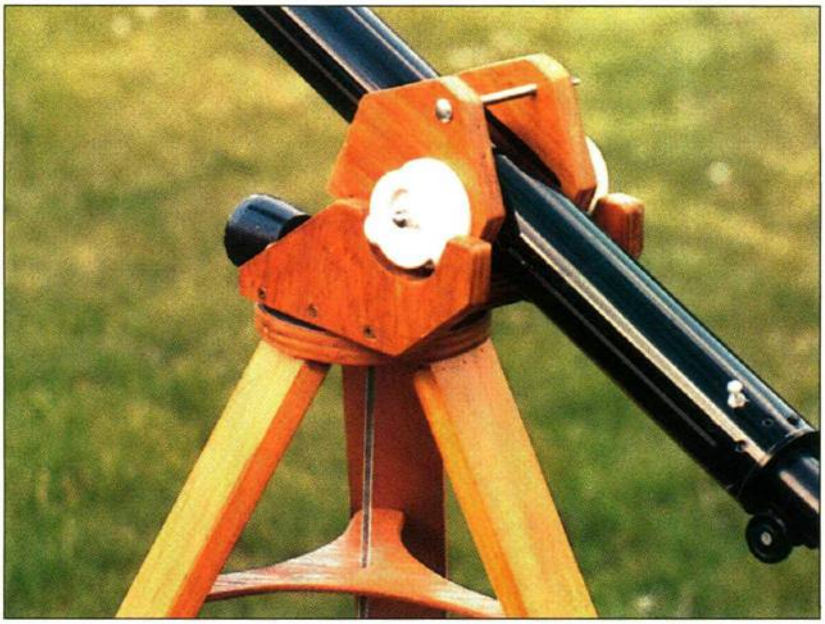
Wood glue
Contact adhesive
Wood filler
Sandpaper
Paint or stain and varnish
To paint the mount, use a high quality latex gloss enamel, otherwise, use water base stains with a compatible water-based polyurethane varnish.

Hardware

3 2½" hinges with screws
1 ¼" by 4" carriage bolt
2 ¼" tapered head bolts 2" long
7 plastic foot pads (sometimes called "glides", designed to go on the legs of furniture)
1 ¼" x 12" threaded rod
4 ¼" nuts, three ¼" wingnuts, seven ¼" washers, twelve 1⅝" gold/zink screws (or wood screws).
Felt 5" x 7" (self adhesive if possible)
Formica 8" x 8" scrap, smooth texture (linoleum floor tile will do)



The bottom board with a 1/4"-20 bolt protruding to fit into the cradle box



The finished mount with telescope loaded and ready to use. Add a small counterweight to the front of the cradle box if needed for better balance.

to the base in an equilateral triangle on the underside of the base. Mark the positions for pilot holes.

Next, hold one of the legs with one hand while the other hand holds the hinge at the end of the leg. Estimate the placement of the hinge so it will make about a 60° angle to the base when the leg is extended. It's best to attach the hinges so the angle is more nearly perpendicular to the base — you can always sand off a bit of material from the outer edge of the leg to increase the angle. After pre-drilling small holes for the screws, attach the hinges to the legs. Invert the base, put it on a flat and level surface and insert the screws in the pre-drilled holes in the base.

Use two nuts and washers to attach the 12" threaded rod which holds the cradle box in place and pulls up the tension triangle, holding the legs in position. Allow the rod to protrude about an inch at the top to engage the cradle box. You might have to countersink the top nut to prevent it from contacting the underside of the cradle box. Tighten the two nuts so the threaded rod does not rotate. Attach the tension triangle loosely to the lower end of the threaded rod with a washer and wing nut. Install the cradle box and bearing box with the telescope tube.

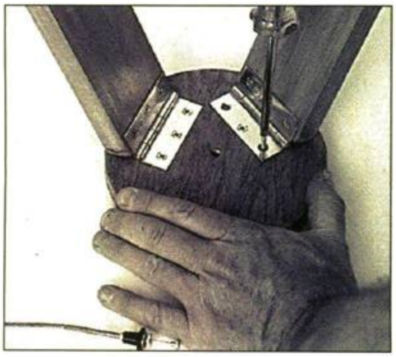
Try It Out

Make sure the mount has complete range of motion. Install the telescope tube and adjust the balance by sliding it backward or forward in the bearing box, adjusting the "squeeze" as necessary. It is designed to be easy to change. To operate the tension triangle, rotate it so the legs are pushed outward and tighten the wing nut. For storage, loosen the wing nut and rotate the triangle again, then collapse the legs.

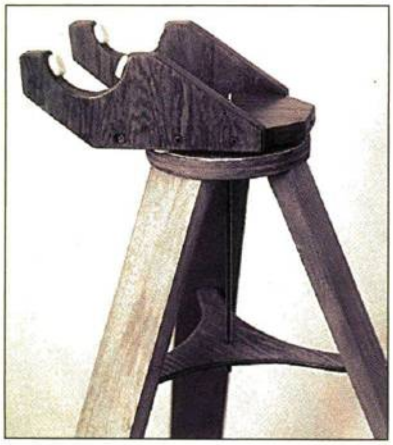
If needed, add a counterweight to the front of the cradle box to compensate for the telescope weight.

Your finished product is now far superior to the "old" department-store telescope. It's sturdier and easier to use, and is a good starter for observing the Moon, planets, and double stars, while providing many hours of uncomplicated observing pleasure. □

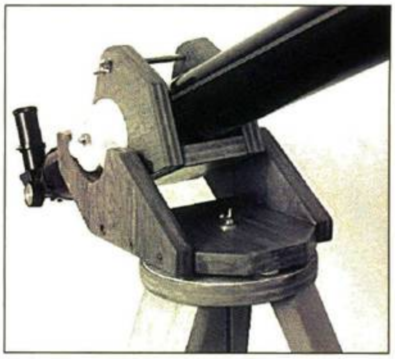
David Trott teaches college astronomy classes in Denver, Colorado, and telescope making at Gates Planetarium.



Pre-drilling the screw-holes for the hinges will make attaching the legs much easier.



Cradle box attached. Note the tension triangle wedge placed to keep legs spread.



The scope held securely in the side-bearing box fits neatly inside the cradle box.

EXPLORING South

A host of faint gas clouds lies scattered across the southern sky — do you have the tenacity to track them down?

by Richard Jakiel

Mike Simmons

The bluish nebula NGC 1973–5–7 in Orion, below and left of M42.

The southern Milky Way calls us out under the stars despite winter's icy grip. Normally we look at the bright showpieces of the winter sky, from the Orion Nebula (M42) to the Pleiades. But other, less obvious treats lurk in the background, vying for attention from tenacious observers who wait for black skies and clean transparency to pull them in. Stretching in a huge arc from the Orion Nebula to the Vela Supernova Remnant in the far south lie three complexes of nebulosity worth checking out — the Orion, Seagull, and Vela SNR–Gum Nebula groups. These complexes include a few showpieces along with objects that will test the largest telescopes and most seasoned deep-sky enthusiasts.

The Orion Complex

The most familiar to northern observers is the Orion Complex, which includes the wonderfully intricate Orion Nebula, the Dagger (IC 434, the nebula that outlines the dark Horsehead Nebula), the Pi (π) Orionis or Flame Nebula, Barnard's Loop, and a host of smaller objects. We'll skip the Orion Nebula (see "The Secrets of Orion's Great Nebula," December 1995) and move straight to a lesser-observed reflection nebula lying nearby, **NGC 1973–5–7.** This pretty nebula surrounds several bright stars and is located less than ½° north of M42. It's easily visible in even modest backyard telescopes. Close inspection reveals several dark lanes that divide the nebulosity into knots, hence the triple NGC designation. Just off the southern outskirts of M42 lies the pale glow of NGC 1980. Like NGC 1973-5-7, it is overshadowed by nearby M42, but its delicate glow is well worth the effort.

The area surrounding Zeta (ζ) Orionis contains a multitude of challenging treasures. Extending southward from Zeta is the faint emission nebula **IC 434,** sometimes called the Dagger. The **Horsehead Nebula** (B33) is a small dark nebula that obscures part of the strip of IC 434. Seeing the Horsehead is a challenge but the exercise is much aided by deep-sky filters such as the H-β and to a lesser degree UHC filters, which permit the Horsehead to be seen with a 10- or 12-inch scope. Nearby, you may see **NGC 2023** and **IC 435,** smaller patches of bright nebulosity surrounding illuminating stars.

Just east of Zeta lies the much brighter emission nebula **NGC 2024,** made somewhat difficult to see because of the glare from bright Zeta. The nebula spans 20' and is crisscrossed by a series of dark rifts. The most prominent runs nearly north-south, with numerous indentations and side branches. The pattern of dark rifts has led to interesting names as the Flame Nebula, though I prefer the Tank Track Nebula.

Of all the nebulae in the Orion Complex, by far the most challenging to observe visually is the huge, extremely faint arc known as Barnard's Loop. Discovered by Edward E. Barnard photographically in the late 19th century, it is part of an immense shell of hydrogen gas that covers much of the constellation, the product of intense winds from nearby O and B stars. Although easy to photograph, Barnard's Loop is far more difficult to observe. A wide-field telescope with a nebula filter and dark, contrasty skies are recommended for success.

Around the Seagull

The **Seagull Nebula** (IC 2177, Gum 2) is a large, luminous arc of gas that straddles the Canis Major–Monoceros border. It's probably a supernova remnant. A popular target for astrophotographers due to its huge size, the Seagull may be found by moving north from Sirius to Theta (θ) Canis Majoris, and then proceeding about 2.5° east. On the southern tip of the Seagull you'll find **Cederblad 90,** a small, moderately

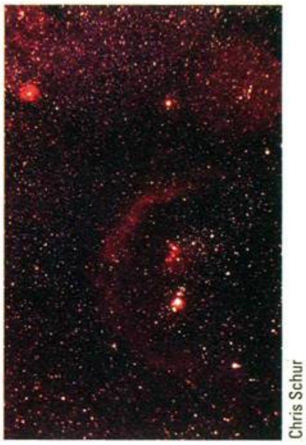
ern Nebulae

bright glow surrounding a 7th-magnitude star. Moving northward brings you to **NGC 2327**, another bright knot. This small reflection nebula surrounds a 10th-magnitude star. Along the northern wing of the Seagull lie several small clusters embedded in a rich star field.

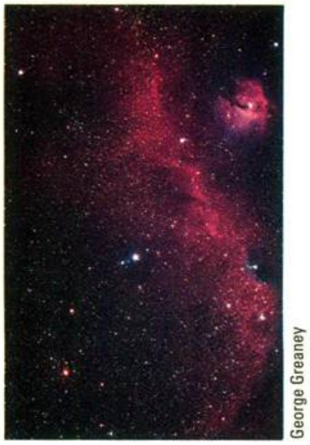
Next, check out **NGC 2359** (Gum 4), some 4.5° west of the bright open cluster M47 in Puppis. The freakish shape of this emission nebula has given it a multitude of nicknames, including Thor's Helmet. The central bubble (the helmet) is actually a shell of gas blown out from the Wolf-Rayet star W–R–7. Two partial shells are also visible, the brighter projections in the east forming the horns, while the more subtle shell remnants in the west form Thor's hair. These are best viewed with an O III filter and make an exquisite sight in 10-inch or larger scopes. Using smaller scopes will necessitate waiting for a clear, dark night.

The Gum Nebula Complex

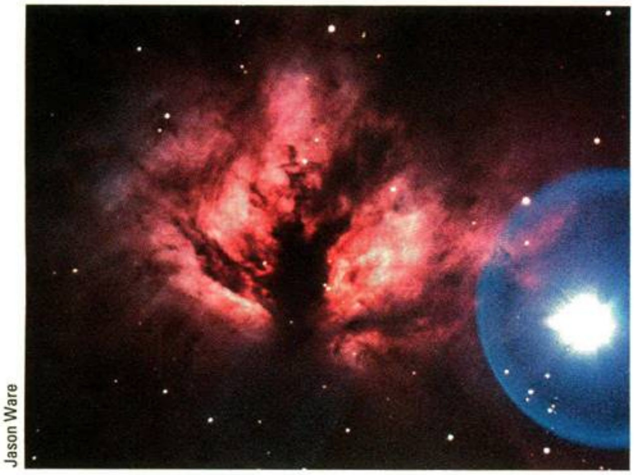
Farther south, the **Gum Nebula** consists of a gigantic matrix of emission and reflection nebulosity covering a major portion of the southern winter Milky Way, spanning more than 30°. It was discovered photographically by the Australian astronomer Colin S. Gum in 1952. Much of the nebula complex is too faint to be detected visually, although many of the brighter parts have NGC and other designations. Some of the brighter pieces can be found close to the Seagull Nebula region. One of these is **Sharpless 2–301** (Gum 5), a small patch of nebulosity nearly 7½° south of IC 2177. In my 13.1-inch scope with an O III filter, it appeared as a bright, wedge-shaped glow measuring less than 10' across.


Chris Schur

Barnard's Loop, the reddish arc covering much of central Orion, resulted from intense stellar winds from nearby hot stars.


George Greaney

The Seagull Nebula (IC 2177) on the Canis Major–Monoceros border is so faint that it challenges the sharpest-eyed observers.


Jason Ware

Emission nebula NGC 2024, immediately east of the bright star Zeta Orionis, is bisected by a broad dark band of dust.

Near the center of the Gum Nebula complex lies a most remarkable structure, the **Vela Supernova Remnant**. Not actually a part of the Gum Nebula, its identity is often confused with the Gum, and in many references and star atlases it is misidentified. The Vela Supernova Remnant forms a huge curved arc of nebulosity more than 6° long, with many intricate side branches and filaments. It covers several times the area of the much better known Veil Nebula in Cygnus.

Deep-sky observer David Riddle, who bagged this object with a 15-inch scope and an O III filter, describes it as "a filament over 4° long, brightest on the western end. A prominent hook defines the eastern end. It is about as bright as the Veil Nebula as seen in an 8-inch scope." Veteran observer Tom Polakis noted the "intricate detail of the filaments, and its resemblance to the Veil, but on a much larger scale." Under dark skies, large scopes will reveal all the major filaments plotted on *Uranometria 2000.0*.

Several other fragments of the Gum Nebula are visible in this region. **NGC 2626** is a diffuse patch of nebulosity less than 5' across. Another small patch, Gum 15, surrounds a 6th-magnitude star in the sparse open star cluster Collinder 197. Somewhat easier to observe is **Gum 23**, a moderate sized, weak glow. These objects are best observed with nebula filters and moderate or large telescopes. If you have access to dark, southern skies, take some time and explore these lesser known nebulae of the winter Milky Way. □

Richard Jakiel is an avid deep-sky observer living in Atlanta. He has written several articles for ASTRONOMY *and for* Deep Sky.

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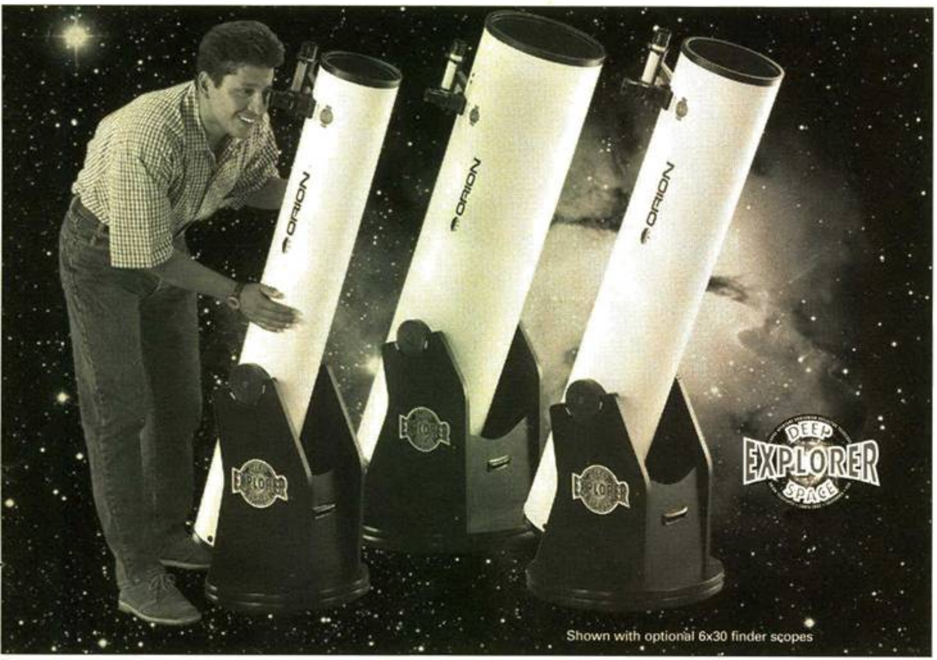

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The classic 5" f/10 Schmidt-Casegrain is incredibly portable. Ideal for both astronomical and terrestrial viewing and astrophotography. Includes built-in motor drive, fork mount and equatorial wedge, 5x24 finder, 90° diagonal, and 25mm (50x) 1.25" SMA eyepiece. Weighs 23 lbs.

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Mfr's List $1758 ~~$1049~~ #9198 **$949** (25.69)

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ShortTube™ 80mm Refractor

NEW!

Here's a compact 400mm f/5 scope that's great for both daytime nature viewing and casual stargazing. Features a fully coated 80mm objective lens, rack-and-pinion focuser, 45° erect-image diagonal, TWO 1.25" Kellner eyepieces—25mm (16x) and 10mm (40x)—and a 6x30 finder scope with long-stem bracket. Telescope attaches quickly to any photo-type tripod. Highly portable—take it anywhere!

#9086 **$249** (9.22)

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Deep Space Explorer™ Dobsonian Telescopes

6", 8", & 10" Deep Space Explorers

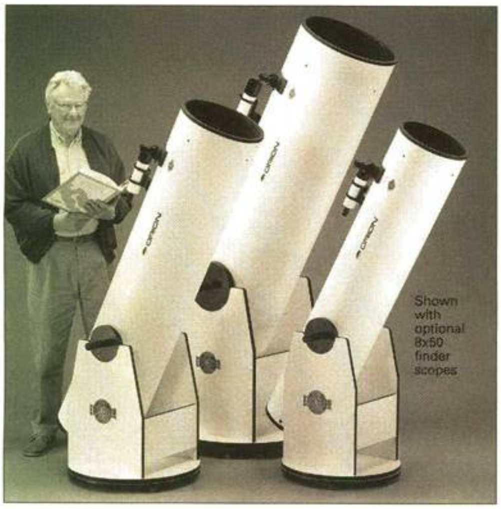
Deep Space Explorer Dobsonians are the "gold standard" in high-performance, low-cost telescopes. Their clean simplicity, rugged durability, and uncompromising optical quality make them ideal for both beginning and intermediate skygazers. They deliver bright, jaw-dropping views of the heavens—you'll be amazed! The wood cabinet Dobsonian mount features zero-backlash teflon bearings for effortless telescope movement, making it easy to manually track objects. Each scope comes equipped with an aluminum low-profile helical focuser and a fully coated 26mm Sirius Plössl 1.25" eyepiece. As an added bonus, we're including FREE a 5x finder scope and mounting bracket—a terrific value!

Now with FREE 5x Finder Scope!

6" f/8	#20401 **$319**	(39.00)
8" f/6	#20402 **$419**	(49.00)
10" f/4.5	#20405 **$649**	(69.00)

10", 12.5", & 16" Premium Deep Space Explorers

Advanced large-aperture deluxe models featuring Pyrex mirrors and enhanced aluminum optical coatings with 94% reflectivity for brightest images. Also formica/teflon bearings for buttery smooth movements, and oversized 4-vane fully adjustable secondary mirror support. Unique optical tube handles allow easy lifting of telescope tube.



Shown with optional 8x50 finder scopes

Comes with high-quality 26mm Plössl eyepiece and NOW with your choice of focuser!

	2" Low Profile	1.25" Rack & Pinion	2" Rack & Pinion	2" Crayford	S&H
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12.5"	#9914 **$969**	#9923 **$989**	#9920 **$1029**	#9917 **$1069**	(79.00)
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SKYVIEWS COME FULLY LOADED!

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- Durable aluminum optical tubes resist dents and rust.
- Sturdy equatorial mount with worm-gear tracking controls.
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- Smooth 1.25" rack-and-pinion focuser.
- Achromatic 6x30 finder scope with two-ring bracket.

SkyView™ 90mm Refractor

This fantastic refractor telescope features a big 90mm (3.5") multi-coated f/11 achromatic objective lens for superb images. Especially suited to planetary, lunar, and stellar observation. It provides spectacular views of star clusters and nebulas. Includes 90° prism diagonal.
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Orion Light-Pollution Filters

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SkyGlow™ Broadband Filters

Rated the #1 broadband filter by *Sky & Telescope* (7/95): " I Found the Orion SkyGlow to be the most useful."

For slightly to moderately light-polluted areas.

.965" Broadband Filter fits .965" eyepieces. #5661 **$44.95** (2.98)

1.25" Broadband Filter fits 1.25" eyepieces. #5660 **$69.95** (3.45)

2" Broadband Filter fits 2" eyepieces. #5659 **$109** (3.45)

SC Broadband Filter fits rear cell of Meade and Celestron Schmidt-Cassegrain scopes. #5658 **$89.95** (3.45)

Moon Filters

Cuts 87% of the light from the Moon, reducing glare to reveal more detail and help preserve night vision.

.965" #5664, **1.25"** #5662 **$15.95** (2.43)

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"The UltraBlock gave superior results." *Astronomy* (2/91)

For severely light-polluted areas and faint nebulas.

.965" UltraBlock Filter fits .965" eyepieces. #5655 **$79.95** (2.98)

1.25" UltraBlock Filter fits 1.25" eyepieces. #5654 **$99.95** (3.45)

2" UltraBlock Filter fits 2" eyepieces. #5657
SC UltraBlock Filter fits rear cell of Meade and Celestron Schmidt-Cassegrain scopes. #5656 **$149 each** (3.67)

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Full-aperture optical glass filters, for superb images and safe viewing of the Sun. Great for both visual and photographic use. Fits over front of telescope.

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Many other sizes available. See our free catalog for details.

Color Eyepiece Filters

Made from absolutely the highest-quality photo-grade optical glass, anti-reflection coated. Ideal for contrast-enhancing planetary and lunar observations and photography with any telescope. Black-anodized aluminum cell threads into any standard eyepieces, or into our universal camera adapters.

.965" Set of 4 #80A Medium Blue, #58 Green, #25 Red, #15 Yellow. #5510

1.25" Starter Set of 4 #80A Medium Blue, #58 Green, #25 Red, #15 Yellow. #5514

1.25" Expansion Set of 4 #21 Orange, #47 Violet, #11 Yellow-Green, #82A Pale Blue. #5516

1.25" Advanced Set of 4 #8 Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green. #5570

$49.95 each (2.98)

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Individual Filters
.965" and 1.25" $14.95; 2" $32.50

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CELESTRON

Ultima Series

Fully multi-coated for peak performance, Ultima 1.25" eyepieces are hybrid designs of 4 to 7 lens elements with blackened edges. Choose from a wide range of focal lengths. All are threaded for filters, have rubber grip rings and rubber eyecups. Apparent fields: 51° (7.5-24mm), 50° (5mm,30mm), 49° (35mm), 36° (42mm). Buy now at bargain prices!

Save $10!

5mm	*Mfr's List $156*	#8670	~~$80~~ **$79**	(3.45)
7.5mm	*Mfr's List $136*	#8672	~~$78~~ **$68**	(3.45)
12.5mm	*Mfr's List $146*	#8673	~~$83~~ **$73**	(3.45)
18mm	*Mfr's List $160*	#8674	~~$93~~ **$83**	(3.45)
24mm	*Mfr's List $176*	#8677	~~$99~~ **$89**	(3.45)
30mm	*Mfr's List $182*	#8678	~~$106~~ **$96**	(3.67)
35mm	*Mfr's List $210*	#8679	**$119**	(3.67)
42mm	*Mfr's List $210*	#8680	**$127**	(3.67)

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Ultrascopic™ Eyepieces

With Superb, High-Performance Ultra™ Multi-Coatings!

Ultrascopic eyepieces yield the highest contrast, greatest light transmission, and best overall image fidelity obtainable. With a superior 5-element design and Ultra™ Multi-Coatings on every surface, they outperform 4-element eyepiece designs. Wide 52° field of view. Removable contoured rubber eyeguard. The 5mm and 3.8mm feature advanced 7-element designs with surprisingly long eye relief. Guaranteed to knock your socks off!

Reduced Up To $20

Medium-High Power 5-Element 1.25"
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 ~~$89~~ **$79 each** (3.45)

Wide-Field 5-Element 1.25"

25mm Ultrascopic	#8564	~~$99~~ **$89**	(3.45)
30mm Ultrascopic	#8562	**$119**	(3.45)
35mm Ultrascopic	#8560	**$139**	(3.45)

High-Power 7-Element Long Eye Relief 1.25"

5mm Ultrascopic	#8574	~~$109~~ **$89**	(3.45)
3.8mm Ultrascopic	#8576	~~$109~~ **$89**	(3.45)

ORION

Sirius™

Quality Plössl 1.25" Eyepieces

Fantastic Fully Coated Eyepieces at an Incredibly Low Price!

You could pay twice the price for other brands of Plössl eyepieces, but why? Sirius Plössls are top-quality, 50° apparent-field (43° 40mm) eyepieces that yield extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The classic 4-element Plössl design is renowned for its fantastic performance. The Sirius Plössl's fully-coated optics are mounted in black-anodized aluminum housings with chrome-plated brass barrels for durability and precision fit. Available in 1.25" barrels only.

7.5mm #8738, **10mm** #8736, **12.5mm** #8726, **17mm** #8734, **20mm** #8733, **26mm** #8732 **$49.95 each** (3.45)

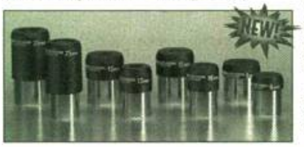
32mm #8728, **40mm** #8730 **$59.95 each** (3.67)

SPECIAL OFFER!

Get a FREE Orion Eyepiece & Accessory Case (#5951) with purchase of four or more Orion Sirius Plössl eyepieces! A $19.95 value!

Dimensions: 11"x7"x3". For description, see eyepiece cases below. Offer expires Dec. 31, 1996.

Orion Explorer II™ Eyepieces



Reliable Performance, Remarkable Value!
Orion's Explorer II models are attractively priced for even limited budgets. Their 3- and 4-element fully coated glass lens configurations provide a pleasing 50° apparent field of view. Threaded for filters.

1.25" Explorer II
25mm #8150, **13mm** #8151, **10mm** #8152, **6mm** #8153 **$34.95 each** (3.45)

.965" Explorer II
25mm #8130, **13mm** #8131, **10mm** #8132, **6mm** #8133 **$29.95 each** (2.98)

PENTAX

Pentax SMC XL-Series

Wide-Angle Premium Eyepeices
With a 5- to 7-element lens configuration that yields a luxurious 65° apparent field, these eyepieces offer truly heavenly views. They feature Pentax's Super-Multi-Coating (SMC) and long 22mm eye relief. One look and you'll be hooked!

7mm 1.25"	#8221	**$289**	(3.67)
10.5mm 1.25"	#8222	**$279**	(3.67)
14mm 1.25"	#8223	**$279**	(3.67)
21mm 1.25"	#8224	**$279**	(3.67)
28mm 1.25"	#8225	**$289**	(3.67)
40mm 2"	#8226	**$319**	(4.11)

TeleVue

Panoptic Eyepieces

Six-element design delivers tack-sharp images, a wide 68° apparent field, and long eye relief.

15mm 1.25"	*Mfr's List $270*	#8339	**$219**	(3.71)
22mm 1.25"/2"	*Mfr's List $355*	#8341	**$279**	(4.11)
27mm 2"	*Mfr's List $425*	#8338	**$329**	(4.71)
35mm 2"	*Mfr's List $359*	#8340	**$359**	(5.71)

Nagler Eyepieces

The ultimate visual experience! Unbelievably wide 82° apparent field provides incredible views.

4.8mm 1.25"	*Mfr's List $205*	#8330	**$189**	(3.67)
7mm 1.25"	*Mfr's List $255*	#8333	**$229**	(3.67)
9mm 1.25"/2"	*Mfr's List $305*	#8331	**$259**	(4.11)
13mm 1.25"/2"	*Mfr's List $350*	#8332	**$319**	(4/11)
Nagler Type 2				
12mm 1.25"/2"	*Mfr's List $355*	#8337	**$289**	(4.71)
16mm 1.25"/2"	*Mfr's List $395*	#8336	**$319**	(4.71)
20mm 2"	*Mfr's List $490*	#8335	**$409**	(5.71)

We also carry Tele Vue Plössls. See our catalog.

ACCESSORIES

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Barlow Lenses

Double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25", and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.

.965" 2x Barlow	#8740	**$39.95**	(2.98)
1.25" 2x Barlow	#8746	**$49.95**	(2.98)
2" 2x Barlow	#8724	**$89.95**	(3.95)

VariPower 2x–3x Barlow
Our most versatile barlow. Adjusts to any magnification between 2x and 3x. Fully multi-coated optics. 1.25" barrel. #8748 **$69.95** (3.45)

Shorty™ Barlows
About half the length of our regular barlows for added convenience. Magnifies 2x or 3x when positioned behind or in front of diagonal, respectively, on a refractor or Schmidt-Cassegrain. Works in all scopes, including those in which longer barlows won't work.

.965" Shorty Barlow	#8710	**$49.95**	(2.98)
1.25" Shorty Barlow	#8711	**$49.95**	(3.45)

ORION

90° Star Diagonal Prisms

Orion's multi-coated diagonals are ideal for refractors and Schmidt-Cassegrains.

.965" Star Diagonal	#8761	**$29.95**	(2.98)
1.25" Star Diagonal	#8763	**$39.95**	(2.98)
Hybrid 1.25"/.965"	#14008	**$39.95**	(2.98)
1.25" Correct Image	#8787	**$89.95**	(2.98)

Ultra™ 2" Diagonals

2" Prism Diagonal Absolutely the finest-quality multi-coated 2" prism for highest light transmission.
For refractors #8770, **for Schmidt-Cassegrain** #8771 **$219** (4.71)

2" Mirror Diagonal Affordable, high-quality first-surface optical flat star diagonal.
For refractors #8773, **For Schmidt-Cassegrain** #8772 **$109** (3.45)

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Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute set-up—no polar alignment or levelling.
- For ANY telescope, with or without a motor drive. Even altazimuth or Dobsonian scopes!
- Digital display of celestial coordinates (RA and Dec).
- Built-in electronic sky catalog—find objects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a 9v battery or external 12v power supply (not included).

Sky Wizard Model 1
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Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice. Weighs just 6 oz. #7802 **$249** (4.44)

Sky Wizard Model 3
Gigantic 10,000 object database, including entire NGC and IC and 837 interesting double and variable stars. Expanded object descriptions, RS-232 port. #7803 **$349** (6.78)

Complete system requires Sky Wizard Model 1, 2, or 3, and a telescope installation package, sold separately.

Installation Packages
Includes two encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions. Installation packages are available for most telescope models. Call for details. **from $166**

If You Take Your Computer With You . . .
NEW! Sky Wizard CTI
Computer–Telescope Interface

This handy, portable device connects the encoders on your telescope directly with your computer, allowing you to monitor your telescope's location with **TheSky** and **Deep Space** software programs (not included). Interface not needed with SkyWiz 3. #7810 **$149** (4.11)

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35mm Film for Astrophotography

Just in time for Comet Hale-Bopp, we've added a huge selection of films for astrophotography with your 35mm SLR camera. Here's just a sample.

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Konica SR-G 3200, 24 exp.	**$9.98**	(1.34)
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Fujichrome 400, 24 exp.	**$9.98**	(1.34)
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Astronomically correct red LED preserves dark adaptation. Shock-proof yellow plastic body is easy to find in the dark. Two AA batteries INCLUDED. #5744 **$11.95** (2.98)

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Mini Giant 8x56 and 9x63

NEW!

Orion Mini Giant™ 8x56 and 9x63

Get a front-row view of the Comet Hale-Bopp show with a pair of Orion Mini Giants! The Mini Giant 8x56 and 9x63 models will provide grand views, offering wide apertures for excellent light-gathering power, moderate magnification, and a nice wide field of view.

Mini Giant binoculars bridge the gap between traditional 7x50 "night glasses" and larger 70mm and 80mm "giant" models. The big 56mm and 63mm objective lenses collect plenty of light for viewing faint celestial objects. BAK-4 porro prisms and fully multi-coated optics deliver the highest degree of light transmission and contrast.

Orion Mini Giants are easily hand-holdable, but are also threaded to accept an optional tripod mounting bracket. They feature smooth rubber armor for a good grip, a large knurled center focus wheel, right diopter adjustment, and fold-down rubber eyguards. Eye relief is a comfortable 18mm, long enough to see the whole field of view even with eyeglasses or sunglasses on. Includes hard case with shoulder strap, lens caps, and Orion's Deluxe Wide Neck Strap.

8x56 Mini Giant

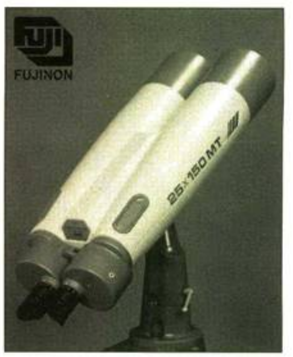
Lighter and smaller than the 9x63 model. 8x magnification, 5.8° field of view. Weighs 32 oz.

#9361 **$179** (5.19)

9x63 Mini Giant

Slightly higher 9x magnification, 5.0° field of view. Weighs 36 oz.

#9363 **$219** (5.71)



Fujinon 25x150 Binoculars

The Discoverer of C/1996 B2, Comet Hyakutake

This is the binocular used to discover one of the most spectacular comets of recent history! Even at 11th magnitude, Comet Hyakutake was no match for this binocular's colossal 6-inch objective lenses, patented EBC multi-coatings, and 25x magnification factor. This is the largest binocular in commercial production. Its cast aluminum housings are built to U.S. military specs. The views will knock your socks off! Eye relief, 18.6mm. Field of view, 2.7°. Weighs 41 lbs. We recommend Fujinon's heavy-duty mount and tripod. *(Note: The Telescope & Binocular Center's 30-day money-back return policy does not apply on these binoculars.)*

25x150 Binoculars	#52458	**Call**
Heavy-Duty Mount	#53393	**Call**
Tripod		**Call**

NEW!

Fujinon 70mm Polaris

Awesome Astro Binoculars

For pure star-probing prowess, Fujinon's renowned 10x70 and 16x70 Polaris binoculars can't be beat. Their flat-field optics reduce distortion and astigmatism to virtually undetectable levels. Every surface of the lenses and BAK-4 prisms are coated with up to 13 layers of Fujinon's EBC coatings for greater than 95% light transmission. Tripod adaptable. Individual eyepiece focus. Includes carrying case and lens caps.

10x70 Long eye relief of 23mm, field of view 5.2°, magnification 10x. Weighs 4.8 lbs.

Mfr's List $1080 #52449 **$675** (8.36)

16x70 For extra high power viewing in dark skies. Eye relief 12.4mm, field of view 4.0°, magnification 16x. Weighs 4.8 lbs.

Mfr's List $1150 #52455 **$699** (8.36)

ORION

NEW!

Orion 50mm Scenix™

High-Quality Binoculars at a Remarkably Reasonable Price

Value-minded observers will appreciate these reliable yet highly affordable field glasses. Every air-to-glass optical surface is antireflection coated, and the objective lenses are even multi-coated for additional light transmission and contrast enhancement. The binocular housing is constructed of sturdy metal, not plastic, and includes a sure-grip rubber covering, a center focusing wheel, plus roll-back rubber eyeguards. Each includes a rugged soft-vinyl carrying case with Velcro closure, lens caps, and a neck strap. Both models have a tripod adapter socket.

7x50 A wonderful model for binocular astronomy as well as for scenic daytime viewing. Bright 7mm exit pupil and a 7.1° field of view. Weighs 28 oz.

#9342 **$96** (4.44)

10x50 Perfect higher-power astronomy binocular that's equally well suited for long-distance terrestrial observing. Uncommonly wide 7° field of view. Weighs 28 ozs.

#9343 **$96** (4.44)

ORION

Orion 50mm Explorer™

High-Performance Ergonomic Design

High-performance, economical binoculars with BAK-4 prisms and multi-coatings. Great for both stargazing and daytime viewing. Rubber body coating for sure grip. Includes case, neck strap, and lens caps.

7x35 A terrific all-purpose binocular. Good under both daylight and twilight conditions. 10mm eye relief, 7.6° field of view. Weighs only 20 oz.

#9302 **$138** (3.95)

8x40 Excellent for birdwatching and lon-distance viewing. These 40mm offer excellent brightness. 6.5° fiewld of view.

#9304 **$138** (3.95)

7x50 Ideal for dark sky astronomy and general purpose terrestrial observation. 6.8°field of view

#9306 **$147** (4.44)

10x50 Higher magnification model with 5mm exit pupil recommended by astronomy experts. Great long distance daytime binocular. 5.3° field of view

#9308 **$147** (4.44)

ORION

Orion 50mm UltraView™

Superb Binoculars Ideal For Eyeglass Wearers

The perfect binocular for eye- and sunglass wearers. Extra-long 23mm eye relief and unique pop-down eyepiece guard. Fully multi-coated optics for high light transmission and maximum contrast. BAK-4 prisms. Close focus 16'. Weighs 32 oz. Includes soft nylon case, eyepiece rain shield, and neck strap.

7x50 High brightness model is best for deep-space astronomy and nighttime surveillance. Works great for all-around daytime viewing. 6.5° field of view.

#9357 **$188** (4.95)

10x50 Highest power model, well suited for astronomical observation and distant terrestrial viewing. 6.5° field of view

#9351 **$188** (4.95)

Also available in 8x42 model.

ORION

Orion 50mm Vista™

Featherlight High-Performance Binoculars

Top quality high-performance binoculars. Vista binoculars feature high index BAK-4 prisms and fully multi-coated optics on all air-to-glass surfaces for high fidelity images. Lightweight metal alloy bodies with soft-touch leatherette covering. Long 16-22mm eye relief. Featherlight 28 oz. weight. Include hard carrying case, deluxe strap.

7x50 The brightest Vista has breathtakingly bright images and a 6.0° field of view.

#9355 **$258** (5.19)

10x50 High power model for general purpose astronomy and terrestrial viewing. 5.3° field of view.

#9353 **$258** (5.19)

Also available in 8x42 model.

CELESTRON

SALE!

8x56, 9x63 Ultima

Scanning the night sky is a treat with these large-aperture binos. Fully multi-coated, BAK-4 prisms, and long 21mm eye relief. Tripod adaptable. Case and wide neck strap included.

8x56	6.1° field, 31 oz.	~~$349~~	#9596	**$279**	(5.71)
9x63	5.4° field, 35 oz.	~~$399~~	#9542	**$329**	(5.71)

50mm Pro Series (not shown)

A popular choice for those who want a better binocular at a reasonable price. Fully multi-coated optics with BAK-4 prisms insure images of high contrast and clarity. All Pro models are tripod adaptable. They feature a water-resistant, textured covering. A deluxe soft case, neck strap, and lens caps are included.

7x50 Night-Vision Pro The brightest Pro, the 7x50 is an ideal "night glass," but is also useful for daytime and twilight observing. 7.1° field. Bright 7mm exit pupil. Weighs 29 oz.

Mfr's List $280 #9588 **$169** (4.71)

10x50 Long-Distance Pro Ideal for observation at long distances under daytime and dim daylight conditions. 6.5° field, 15mm eye relief. Weighs 30 oz.

Mfr's List $280 #9590 **$169** (4.71)

12x50 Extra High Power Pro The highest-powered Pro, perfect for long-distance viewing under daylight conditions. The 12x magnification requires a steady hand or a tripod. 5.5° field. 10mm eye relief. Weighs 29 oz.

Mfr's List $320 #9591 **$169** (5.28)

8-24x50 Zoom Pro Zoom from low to ultra-high power. An incredibly versatile, one-size-sees-all binocular! Field of view 5.0° at 8x. 14mm eye relief. Weighs 31 oz.

Mfr's List $420 #9589 **$239** (5.71)

ORION

70mm Little Giants™

The standard for hand-holdable high-power astronomy binoculars. Fully multi-coated. Terrific brightness and edge sharpness! Weighs only 58 oz. Includes tripod mounting adapter and deluxe hard case.

10x70 #9501, **14x70** #9494 **$369** (6.97)

80mm Giant Binoculars

For jaw-dropping views of the heavens and Earth, our wide-aperture Giants can't be beat. Fully multi-coated optics and BAK-4 prisms provide fantastic contrast and edge sharpness. 20% more light transmission than "fully-coated." Includes tripod, L-adapter, and, deluxe hard case. Each model weighs 4 lbs., 13 oz.

11x80 Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable. Field of view 4.5°.

#9502 **$469** (8.05)

16x80 Excellent for astronomy and daytime observation.Tripod recommended. Field of view 3.5°.

#9496 **$469** (8.05)

20x80 Highest-power model, perfect for smaller deep-space objects and long-range daytime views. Tripod required. Field of view 3.5°.

#9498 **$469** (8.05)

100mm SuperGiants™

Gigantic, nearly 4"-diameter lenses gulp in the light, gathering 56% more than 80mm binoculars. These fine binoculars feature BAK-4 prisms and fully multi-coated optics for the sharpest, brightest possible images. You'll be astounded by the incredible resolution and wealth of detail you'll see. Who said the universe was mostly empty space!

Each model comes with a platform-type tripod mounting plate for added stability. It mounts on any sturdy photographic-type tripod equipped with a standard 1/4"-20 post. Both binocular models weigh 7.5 lbs. and come with a heady-duty, foam-lined metal case with luggage-style handle.

14x100 SuperGiant Features moderate 14x magnification and a 7mm exit pupil, which is ideal for astronomical observation under dark sky conditions. Individual eyepiece focus, rubber eyepuards. Field of view 3.3°.

#9495 **1299** (14.00)

25x100 SuperGiant High-power 25x magnification and a 4mm exit pupil. Center focus, rubber eyeguards. Field of view 2.6°.

#9497 **$1299** (14.00)

25x100 SuperGiants shown with included adapter plate and optional tripod.

Bogen Field Tripods

Built to meed the demanding durability requirements of professional photographers. Solid support with hard black-anodized finish. Extremely rigid cast-metal tensioned leg hinges for absolutely secure wobble-free connections.

Standard Model Great for spotting scopes, cameras, small telescopes. Extends to 59" and folds to 25". Smooth tilt fluid pan head.

#20703 **$169** (3.95)

Heavy-Duty Model Extremely stable, larger version, extends to 63" and folds to 28". Perfect for larger "Mak" spotting scopes and heavy cameras. Heavy duty fluid pan head with quick release.

#20705 **$199** (4.78)

Ultra Heavy Duty Model Double strut center braced model is very rigid and suitable for big optical tubes and the largest format cameras. Incredible pan head with separate pan and tilt locks. Height to 73", folds to 39".

#20709 **$349** (5.29)

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Orion Deluxe Wide Neck Strap

Replace your thin ordinary strap with this wide woven strap and you'll definitely feel the difference. Ideal for all full size binoculars or 35mm cameras. Adjustable length with nylon connecting strap.

#51980 **$7.95** (2.43)

Binocular Tripod L-adapters

Mount most any binocular with a 1/4-20 front-hinge thread to a standard camera tripod. The large model is ideal for binoculars over 50mm, the small model for smaller models.

Large Model	#5250	**$21.50** (2.43)
Small Model	#5252	**$19.95** (2.43)

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NEW PRODUCTS

Russian Reflecting Telescopes

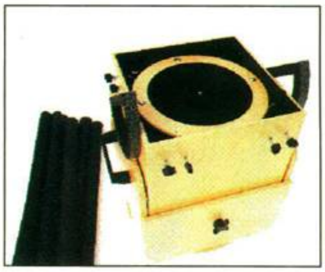
International Optics imports three equatorial telescopes and some accessories from Russia. The Siberia 110 4½-inch f/7.3 Newtonian reflector comes with a 6x30 finderscope, a 3x Barlow lens, a camera mounting bracket, and 15mm Kellner (54x) and 25mm Plössl (32x) eyepieces. The Siberia 150 is a 6-inch f/8 Newtonian that comes with 15mm Kellner (80x), 25mm Plössl (48x), and 42mm Ramsden (27x) eyepieces, as well as a 4x Barlow lens, an 8x50 finder, and a M 42 camera adapter. Both scopes are all-metal construction and ship with motorized German equatorial mounts fitted with setting circles. The Siberia 110 package also comes in a non-motorized version called the TAL 1. Packages include an English user manual, a solar viewing screen, a varnished wooden carrying case, five photo-visual filters, and a solar aperture stop used when projecting an image of the Sun on the solar viewing screen. All models have a 12-month warranty on materials and workmanship, and a 30-day money-back guarantee. International Optics also sells 50mm (50° apparent field of view) Erfle eyepieces and 4½-inch and 6-inch mirror sets with secondaries.

International Optics, Ltd., P.O. Box 6475, Nashua, NH 03063-6475; voice or fax, (603) 595-7978; e-mail, 73554.3420@compuserve.com; Web page, http://Astronomy-Mall.com. Siberia 110 telescope package: $499; TAL 1 package: $359; Siberia 150 telescope package: $679; 4½-inch mirror set: $78; 6-inch mirror set: $115, 50mm Erfle eyepiece: $150. Dealer inquiries welcome.

Compact Truss Dobsonian

Starsplitter introduces the Compact II line of Dobsonian telescopes. As with the company's other line of Compacts, the secondary mirror assembly detaches and stores inside the telescope's rocker box for transport. Compact II features five 1¼-inch-diameter trusses for greater stability. Each scope has Teflon bearing surfaces, wooden groundboard feet, hand-figured Pyrex optics, a Kydex light baffle, a JMI low-profile focuser, an adjustable secondary mirror mount, and a 9-point, cast aluminum primary mirror cell. The mirror box, rocker box, and groundboard are made of varnished Apple-ply plywood. A truss-mounted Telrad finder, a 2-inch focuser, and a light shroud are optional. Compact IIs come in 10-inch f/6, 12½-inch f/4.8, 14½-inch f/4.5, and 15-inch f/4.5 versions.

Starsplitter Telescopes, 3228 Rikkard Drive, Thousand Oaks, CA 91362; (805) 493-2489. 10-inch f/6 Compact II: $1,599; 12½-inch f/4.8: $1,899; 14½-inch f/4.5: $2,399; 15-inch f/4.5: $2,599. Optional accessories: Telrad with rings: $50; 2-inch focuser: $100; light shroud: $90. Crating and shipping are extra; California residents add 7.25% sales tax. Allow 12 weeks for delivery.



New Products presents announcements issued by manufactures. ASTRONOMY assumes no responsibility for the product information supplied. Prices are suggested retail. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha 53187, or newprod@astronomy.com.

Beginners' Astronomy Kit

First Light is a folder of reference materials specifically designed for the beginning skywatcher. A plastic planisphere dials in constellations visible in the night sky for any time of night during any month. A small telescope sky atlas shows the positions of bright deep-sky targets on eight maps that cover the entire night sky. Another booklet describes how to observe with binoculars and what to look for. Other items in the beginners' packet include a 3-year Moon phase calendar, a table of the best meteor showers, a finder chart for Comet Hale-Bopp, and an observing log for duplication.

David Chandler Company, P.O. Box 309, La Verne, CA 91750; (800) 516-9756; (909) 988-5678; fax, (909) 988-5618; e-mail, dschandler@frumble.claremont.edu; Web page, http://www.csz.com/ dschandler. First Light: $24.95, plus shipping — $3 domestic, $6 foreign.

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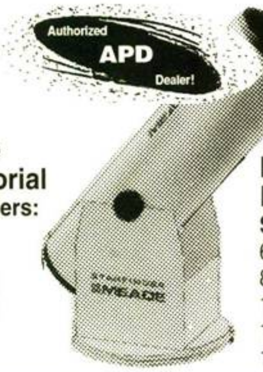

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Super Wide 40	300
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#122 2x 1.25"	$48
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ETX Accy's:

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Adjust. field tripod	149
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2045D Accy's:

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Tripod & wedge	275

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Misc. Meade

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Focuser 70 1.25"	59
Finder 544-8x50	70
Finder 545-8x50	70
Finder 634-6x30	50
Finder brkt-8x50	25
Filter set of 4	50
Filter set of 8	100
Filter set of 12	150
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Piggy bracket 12"	49
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Prism .96-1.25"	30
Prism .96" 45°	43
Prism 1.25" 45°	43
Skylight/seal	48
Star charts	17
Tele extender	30
Tele ext-variable	40
T-adapt: SCT	27
T-adapt: vari-proj	40
T-adapt: 1.25"	30
T-rings	16
Vari pol 905	50
Weight set 7"	88
Weight set 8"	88
Weight set 10"	94
Weight set 12"	104
Wedge 8"	134
Wedge Super	395

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Astrophotograpy for the Amateur	M. Covington, 7x10", 168 pgs.	$18
Amateur Astronomers Handbook	J. Sidgwick, 5x8", 592 pgs.	10
Astronomy for the Beginner	P. Moore, 7x9", 48 pgs.	13
Bright Star Atlas	Wil Tirion, 9x12", 36 pgs.	11
Chasing the Shadow	J. Harris, 7x9", 160 pgs.	19
City Astronomy	R. Scagell, 6x9", 176 pgs.	19
Dictionary of Astronomy	J. Mitton, 5x8", 430 pgs.	13
Discover the Stars	Richard Berry, 7x9", 119 pgs.	13
Messier Album	J. Mallas, 6x9", 248 pgs.	20
Monthly Star Charts	Sky&Tel Mag., 11x14", 68 pgs.	25
New Cosmos	Astronomy Mag., 8x11", 160 pgs.	20
Observers Sky Atlas	E. Karkoschka, 5x7", 131 pgs.	15
Observing Variable Stars	David Levy, 7x10", 198 pgs.	25
Phillips Color Star Atlas	J. Cox, 11x15", 40 pgs.	20
Sky Catalog 2000.0 vol.1	A. Hirshfeld, 9x12", 704 pgs.	40
Sky Atlas 2000.0 Deluxe	Wil Tirion, 11x16", 385 pgs.	45
Star Hopping	A. MacRobert, 9x11", 160 pgs.	22
Turn Left at Orion	G. Consolmagno, 8x11", 205 pgs.	28
The Moon	Astronomy Mag., 8x11", 80 pgs.	12
Urban Astronomer	7x10", 224 pgs.	15
Uranometria 2000.0 vol.1	Wil Tirion, 10x12", 260 pgs.	40

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Leveling wheely bar for Meade 8" or 10" Schmidt-Cass	144
For 12" SCT	189
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Celestron

7x50 Ultima	$280
8x56 Ultima	320
9x63 Ultima	360
20x80 Standard	359
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C5+ $1179

C5 tripod	$259
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Ultima 9.25"	call
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C4.5	call
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Pronto	call
Ranger	call
Ranger Brass	call
Quick Point	40
Starbeam-T	179
2" 90° diagonal	184
1.25" 90° diag	75
Eyepiece proj	69
Ext tube 2 or 3"	33
Bino viewer	call
Gibraltar mt	459
Paracorr 2"	228

Plossl-50°

8, 11, or 15	82
20 or 25mm	94
7.4, 10.5, or 13	70
32 or 40mm	109
55mm	224

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Wide Field-65°

15mm	$136

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15mm	204
22mm	269
27mm	319
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Bar. interface	94

Nagler-82°

4.8mm New!	168
7mm New!	216
9mm	234
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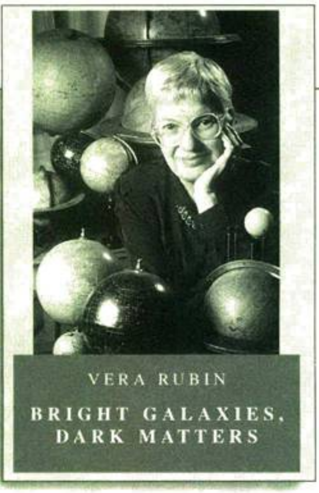

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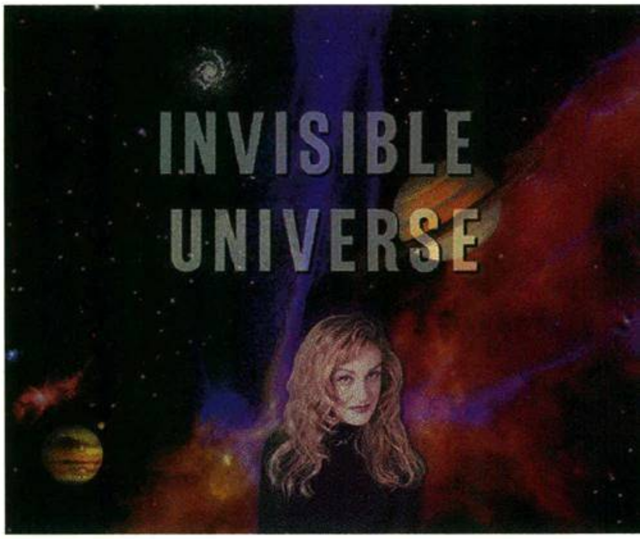
17. I certify that the statements made by me above are correct and complete. Gerald B. Boettcher, Vice President – Finance. Date: October 1, 1996

ASTRO BYTES

Invisible Universe



An entertaining and educational romp through the cosmos, *Invisible Universe* is a unique study of the universe beyond human sight. This CD-ROM contains over 400 photographs and animations of cosmic phenomena and shows how they appear in different wavelengths of light.

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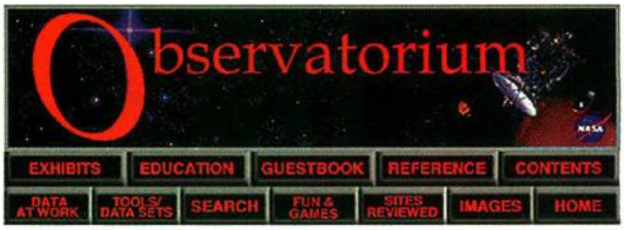

In 1969, NASA put a man on the Moon. In 1996, NASA takes you there and to other places it has visited or observed. NASA's Observatorium web site located at http://observe.ivv.nasa.gov offers an Internet window to the best in NASA Earth and space knowledge. Features include a continually updated "Observation of the Week," "Headlines," and in-depth features on both acclaimed and inconspicuous NASA projects. Of course the NASA favorites will be there — Earth and space photos, the Hubble Space Telescope, planets, comets, black holes, and eclipses. Observatorium combines years of NASA exploration and discovery with the latest web technology, giving visitors a site that's literally out of this world.

NASA's Observatorium, contact Scott Gillespie, email info@observe.ivv.nasa.gov, http://observe.ivv.nasa.gov

Product information is as provided by the developer. Software developers may send new programs and upgrades to AstroBytes, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out ASTRONOMY's home page at **http://www.kalmbach.com/astro/astronomy.html**

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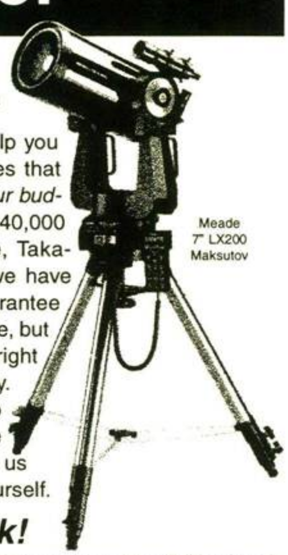

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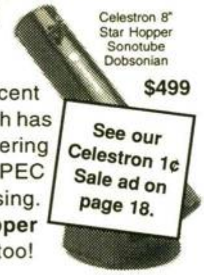

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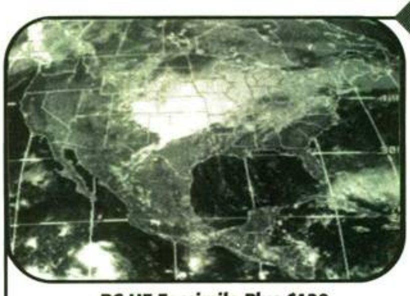

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HR Calc 2.0 Revisited

Some readers are having difficulty downloading the shareware *HR Calc 2.0.* It is not available directly from the developer, and the shareware web site originally published (August 1996) is often busy. Try using the ftp site: ftp://ftp.uoknor.edu/mirrors/SimTel/win3/astronmy/hrcal20.zip.

Integrity
Discussion and Resource Guide

Integrity in Scientific Research

The American Association for the Advancement of Science (AAAS) collaborated with Amram Nowak Associates, Inc., to produce five videos dramatizing realistic situations that raise ethical issues in research. Dramatic presentations leave the participants' dilemmas unresolved, making them ideal for stimulating discussion. The dramas highlight "gray areas" of research where reasonable people might differ over what constitutes a proper course of action. Scientists, post-doctoral fellows, graduate and upper-level undergraduates — anyone who works in a laboratory or is involved in research — may find these videos valuable.

To order, send check or money order to: Science Integrity Videos, AAAS Directorate for Science and Policy Programs, 1200 New York Ave. NW, Washington, DC 20005, Fax (202) 289-4950. Price: $79.95 (AAAS Members $63.96). Add $6.50 for shipping per video set. Email mfrankel@aaas.org, web site: http://www.aaas.org/SPP/DSPP/SFRL/fraud.htm. □

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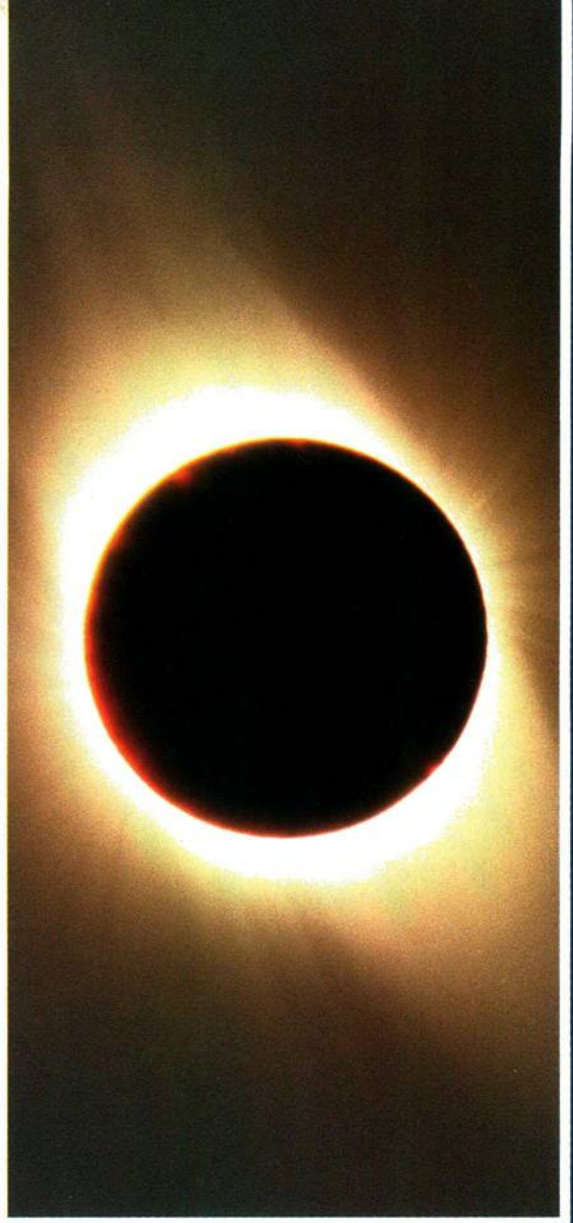

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Astronomy editors Bonnie Gordon, Dave Eicher, and Rich Talcott invite you to daily talks and shipboard constellation watches. Then, on February 26, everyone will view the total solar eclipse through solar-safe filters. All for affordable prices from $1275. A trip you won't want to miss!

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ASTRONOMY

Eclipse photo taken by Ernest Piini.

Visions of Mars

by John Dvorak

The Planet Mars: A History of Observation and Discovery

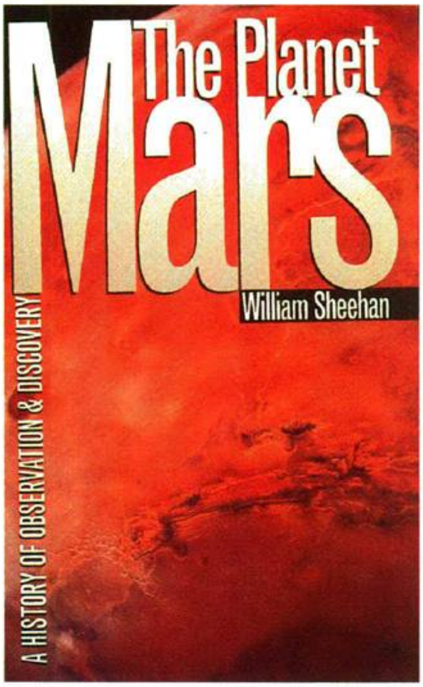
William Sheehan, 271 pages, University of Arizona Press, Tucson, 1997. Clothbound, ISBN 0-8165-1640-5, $45; paperback, ISBN 0-8165-1641-3, $19.95.

Thanks to the small number of spacecraft that flew to the Red Planet more than 20 years ago, the surface of Mars is a real place. At least in our minds, we can run across the red sandy deserts, jump over car-sized boulders, and even fly through the pink martian sky. How we reached our current vision of Mars is described in *The Planet Mars.*

Psychiatrist, amateur astronomer, and astronomy historian William Sheehan has written a detailed history of the exploration of Mars, from the earliest telescopic observations to the successful completion of the Viking orbiter and lander missions. Sheehan's tales of martian exploration are rather technical for a novice trying to launch into a study of the Red Planet. This book is geared more toward the sophisticated reader or researcher of planetary astronomy.

Sheehan weaves together the development of the telescope with the increasing understanding of the true nature of Mars. Improvements in telescope design increased our knowledge of Mars, and the desire to see more detail on Mars prompted the development of better planetary telescopes. The most famous examples are the reported sighting of canals and the building of observatories specifically to view Mars by the French astronomer Camille Flammarion and the American philanthropist Percival Lowell. Both men are examined thoroughly by Sheehan.

Sheehan recounts the influence many late 19th century astronomers played in the controversy over martian canals. Italian astronomer Giovanni Schiaparelli added greatly to the romanticizing of Mars by choosing heroic mythical names for surface features. English astronomer E. Walter Maunder conducted experiments to determine how a series of black spots or black lines on white paper would appear at a distance. W. Wallace Campbell of Lick Observatory detected no water vapor in the martian atmosphere, a result that refuted the claim of water-filled canals on Mars. And Lowell reported seeing canals on Mercury and Venus as well. The debate about martian canals is a complex story in the history of science told well by Sheehan.



Several global maps of Mars produced during the last 120 years are reproduced in *The Planet Mars*, some showing complex networks of canals. A careful reading of this book is a reminder that each map is an artistic expression that combines the then-current knowledge of Mars and the contemporary hope of what Mars might be.

In a similar manner, Sheehan's prophetic comment about the chance of past martian life meshes well with NASA's recent announcement of possible chemical evidence of past martian bacteria found in a meteorite. But are such results, both the sequence of more realistic maps and the recent chemical findings, on the road to scientific truth or a reflection of our inner desires for the Red Planet?

An answer may be forthcoming within the next few decades. After a 20-year lull, we are about to embark on a return to Mars. The return will surely yield a new intimacy with our neighbor planet. When the history of future martian exploration is written, it will dwell on what is yet to come. To understand what has already happened, people of the future will consult *The Planet Mars.*

John Dvorak is a telescope operator and university lecturer in Hawaii.

Other Books

The New Astronomy, Second Edition

Nigel Henbest and Michael Marten, 240 pages, Cambridge University Press, New York, 1996. Hardcover, ISBN 0-521-40324-3, $79.95; paperback, ISBN 0-521-40871-7, $29.95.

Just as red light is but a tiny portion of the visible-light spectrum, the light we see with our eyes is just a tiny portion of the entire electromagnetic spectrum. One of the great developments of 20th century astronomy was the opening up of these other windows to the universe: radio waves, infrared light, ultraviolet light, X rays, and gamma rays. The first edition of *The New Astronomy*, published in 1983, was the first book to compare how various celestial objects appear in different parts of the spectrum. It was widely hailed as an important book for the general public and it exposed a generation of readers to the entire range of the spectrum.

This second edition contains almost 200 new images, from radio to X ray to Hubble Space Telescope photos. Some chapters discuss the different parts of the spectrum, while others discuss the solar system, star birth, star death, and galaxies. This book is sufficiently different from the first edition to make it a worthwhile investment for those who already own the first edition. It is one of the most beautifully illustrated astronomy books, and its sweeping cover-age of astronomy makes it a classic. The writing is accessible, yet at a slightly higher technical level than the typical Astronomy science article.

Feynman's Lost Lecture: The Motion of the Planets Around the Sun

David L. Goodstein and Judith R. Goodstein, 191 pages, W. W. Norton and Co., New York, 1996. Hardcover, ISBN 0-393-03918-8, $35 (includes an audio compact disc).

The late Richard Feynman, a Nobel-prize-winning physicist and self-described "curious character," was renowned for his lectures. In a 1964 lecture to a Caltech freshman physics class, he explained why the planets move around the Sun the way that they do. What made Feynman's presentation unique is that he devised his own proof using high school-level mathematics and geometry. Fortunately, after sitting dormant at Caltech for three decades, a tape of the lecture has been discovered. Now you can hear it for yourself on CD. The accompanying book provides a historical background, Feynman's actual proof, and finally the full text of the lecture (including equations and diagrams). While the lecture will be of most interest to math buffs, the book and CD provide a fascinating glimpse into the mind of one of the 20th century's most eccentric and authentic geniuses.

Popular Physics and Astronomy: An Annotated Bibliography

Roger Smith, 505 pages, The Scarecrow Press, Lanham, Maryland, 1996. Hardcover, ISBN 0-8108-3149-X, $64.

Looking for a book about the Big Bang? This bibliography tells you which one to buy. It lists and describes 895 books, articles, and videos dealing with physics and astronomy that are geared toward the general public. The book is divided into subject matter for easy reference. There's also a chapter on children's books. Each entry describes the level of math in the book, the writer's background, and the presence of photos and illustrations.

Starry Messenger: Galileo Galilei

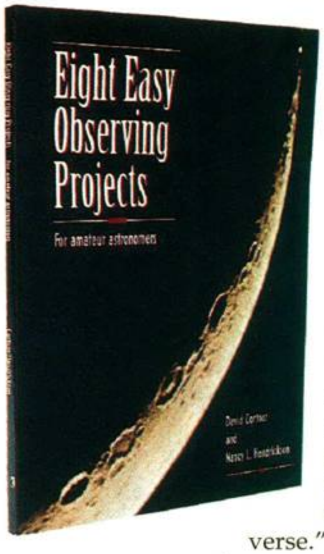
Peter Sís, 32 pages, Farrar, Straus and Giroux, New York, 1996. Hardcover, ISBN 0-374-37191-1, $16.

Author and illustrator Peter Sís has created a children's book about the great Italian astronomer Galileo. Written in fairy-tale-like language, the book is easily understandable to children ages 6 and up. The book discusses Galileo's life and times, his trial, and how his ideas and discoveries withstood the test of time. Paintings by the author illustrate this book.

Eight Easy Observing Projects for Amateur Astronomers

David Cortner and Nancy L. Hendrickson, 160 pages, Kalmbach Publishing Co., Waukesha, Wisconsin, 1996. Paperback, ISBN 0-913135-27-5, $21.95.

What are some easy observing projects for folks who just bought their first telescope? What are some new ideas for those who think they've seen everything there is to see? This book contains the answers. Chapters discuss binocular astronomy, projects for a 60mm telescope, starhopping, lunar observing, how to keep observing logs, astrophotography, what to do on a rainy night, and how to get more deeply involved in national amateur astronomy organizations. From the publishers of Astronomy.


Eight Easy Observing Projects
For amateur astronomers
David Cortner and Nancy L. Hendrickson

The Illustrated A Brief History of Time

Stephen Hawking, 248 pages, Bantam Books, New York, 1996. Hardcover, ISBN 0-553-10374-1, $37.50.

Did you try reading Stephen Hawking's 1988 book *A Brief History of Time*, but just couldn't understand all of it? This updated and expanded edition might be just what the doctor ordered. To make the book more accessible, the new edition is lavishly illustrated with hundreds of photos, paintings, and color diagrams. One can gain a small degree of insight into modern physics just by looking at the pictures and reading the captions. Each chapter has been revised and updated to account for new scientific discoveries, such as the discovery of "ripples" in the cosmic microwave background. Hawking has also added an entirely new chapter about wormholes and the possibility of time travel. An utterly fascinating book from one of the giants of 20th century physics.

Companion to the Cosmos

John Gribbin, 512 pages, Little, Brown and Co., Boston, 1996. Hardcover, ISBN 0-316-32835-9, $29.95.

What's the "free lunch universe?" To find out, check out this new book from British science writer John Gribbin. It is a wonderful reference tool for astronomy buffs, a book that is essentially an encyclopedia of astronomy. Topics are arranged in alphabetical order, and include such things as people, telescopes, classes of astronomical objects, subatomic particles, galaxy and star names, and concepts such as the "free lunch universe." Gribbin's prose is clear and concise, and the book is dotted with occasional photos and illustrations. The book also includes a timeline of important events in the history of astronomy. (OK, OK. A "free lunch universe" is the idea that the universe could have arisen from nothing at all, and contains no net energy. To which Gribbin writes, "If you find this mind-blowing, you are in good company.") □

To order any book, contact your local bookseller with the title, publisher, and ISBN number.

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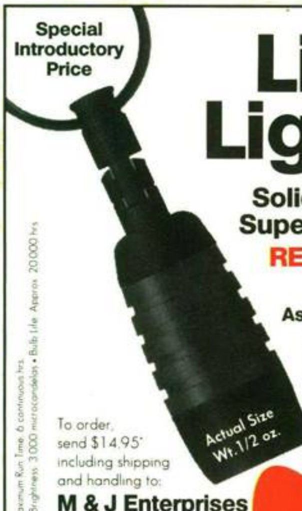

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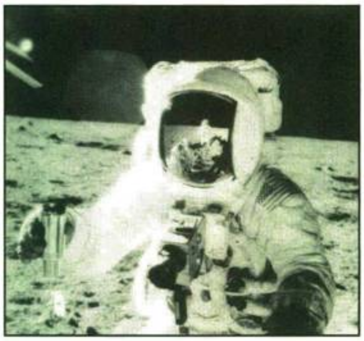

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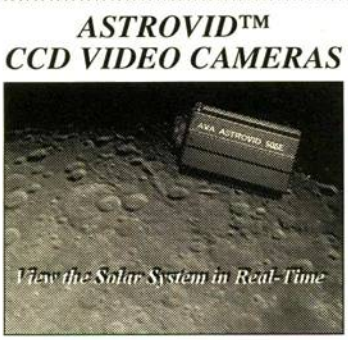

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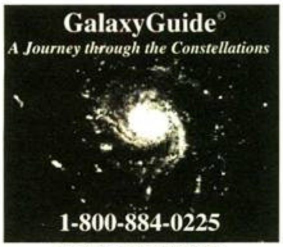

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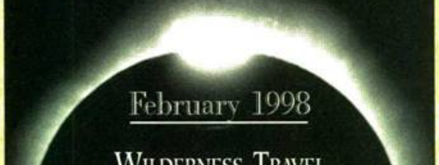
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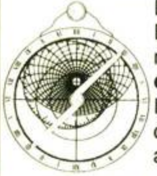

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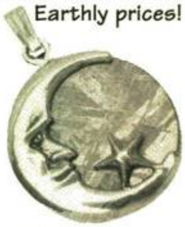

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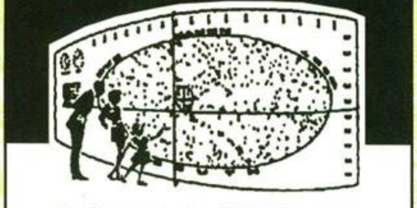

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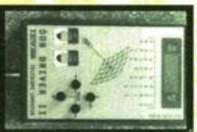

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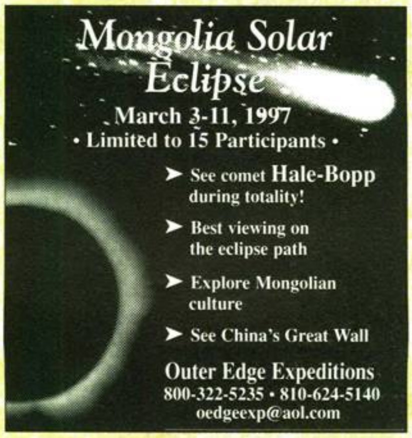

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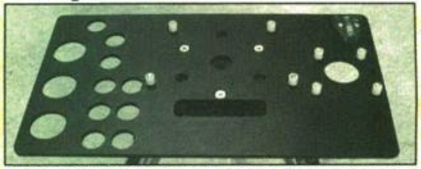

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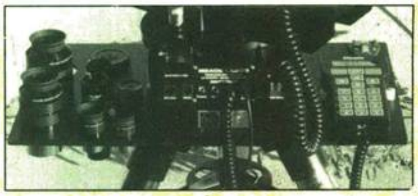

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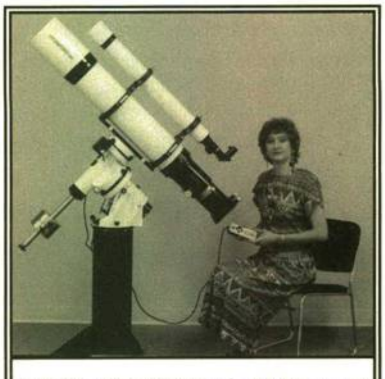

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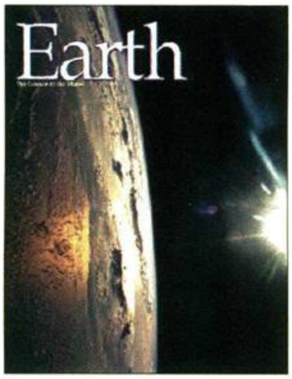

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MEETINGS EVENTS

Cosmic Voyage, Langley Theater, Smithsonian Institution's National Air and Space Museum, Sixth Street and Independence Avenue, S.W., Washington, DC. IMAX film featuring scientific simulations based on data drawn from National Science Foundation cosmology research.

January 10-11
Seventh All-India Amateur Astronomers' Meet, Nehru Planetarium, New Delhi, India. Sponsored by the Amateur Astronomer Association of Delhi. Contact Amitabh Pandey, Nehru Planetarium, Teen Murti, New Delhi 110011, India, telephone, 91-11-3014504 (4:00-12:00 UT), e-mail, aaadel@poboxes.com.

February 3-9
Winter Star Party, Camp Wesumkee, Florida Keys. Sponsored by the Southern Cross Astronomical Society. Contact Bob Grant, 5401 S.W. 110 Ave., Miami, FL 33165, (305) 595-8778, bginsofl@aol.com.

February 6-9
The Orange Blossom Special Star Party, Hickory Hill Observing Complex, near Brooksville, Florida. Sponsored by the St. Petersburg Astronomy Club. Contact Dennis and Ellen Farr, 8811 West Broad Street, Tampa, FL 33615, (813) 884-9111.

February 15
Wagman Winterfest, Nicholas E. Wagman Observatory, Mahaffey Road, Deer Lakes Regional Park, Russellton, Pennsylvania. Free. Contact (412) 224-2510, pzapadka@fyi.net, http://trfn.clpgh.org/orgs/aaap.

March 7-9
First Annual Highlands Stargaze, Nine Mile Grade Campground, Kissimmee River between Sebring and Okeechobee, Florida. Sponsored by the Highlands Stargazers Astronomy Group. Contact Richard Lindblom, 2130 Gresham Street, Sebring, FL 33872, (941) 655-0131, lindblom@ct.net.

Please submit club announcements four months in advance to Meetings and Events, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612, or to tconley@astronomy.com.

RESOURCES PHOTOFACTS

Extreme Stars (page 54)

Stars, by James B. Kaler, Scientific American Library, (W. H. Freeman and Company, 1992). A non-technical introduction to the science of stars, their appearances, births, and deaths. By the author of "Extreme Stars."

Stars, (Time-Life Books, 1989). A beautifully illustrated beginner's guide to the life-cycle of stars.

What Makes Galaxies Change? (page 36)

Voyage to the Great Attractor: Exploring Intergalactic Space, by Alan Dressler, (Random House, 1994). One of the best astronomy books in recent years, talks about galaxies and their role in cosmic evolution. Available in paperback.

Back to Mars on All Sixes (Page 48)

Mars, Edited by H. H. Kieffer, B. M. Jakosky, C. W. Snyder, and M. S. Matthews, (University of Arizona Press, 1992). A full (1,500 pages) and technical treatment of our understanding of the Red Planet, written by scientists specializing in Martian studies.

Mars, by Peter Cattermore, (Chapman and Hall, 1992). An overview of our present knowledge of Mars, written with the layman in mind.

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p. 62: Orion's belt and sword, Bill Iburg, 8-inch f/5 reflector, Ektachrome 400, 8 minutes; **p. 67, top:** Auriga, Kenneth Fye, 50mm f/2, Ektachrome 400, 11 minutes; **bottom, left:** M36, Jack Newton, 16-inch f/5 reflector, Ektachrome 200, 11 minutes; **bottom, center:** M37, Eugene Brings, 8-inch f/5 reflector, hypered Tech Pan 2415, 30 minutes; **bottom, right:** M38, Robert Provin, 6-inch f/6 reflector, Ektachrome 400, 20 minutes; **p. 69:** Quadrantid meteors, Gert Kroner, 40mm f/2.8, T-Max 400, 10 minutes; **p. 68:** Fabio Falchi, 8-inch f/6 reflector, Kodak Elite 100, 10 seconds; **p. 82:** Bill and Sally Fletcher, 5.5-inch Schmidt camera, hypered Royal Gold 100, 12-minute exposure on July 15, 1996; **p. 83:** David Healy, 14-inch f/7 SCT, Scotchchrome 400, 50-minute exposure on April 29, 1996; **p. 84:** Gerald Rhemann and Franz Kersche, 50mm lens at f/2, Kodak Gold 400 Professional, 5-minute exposure on July 13, 1996.

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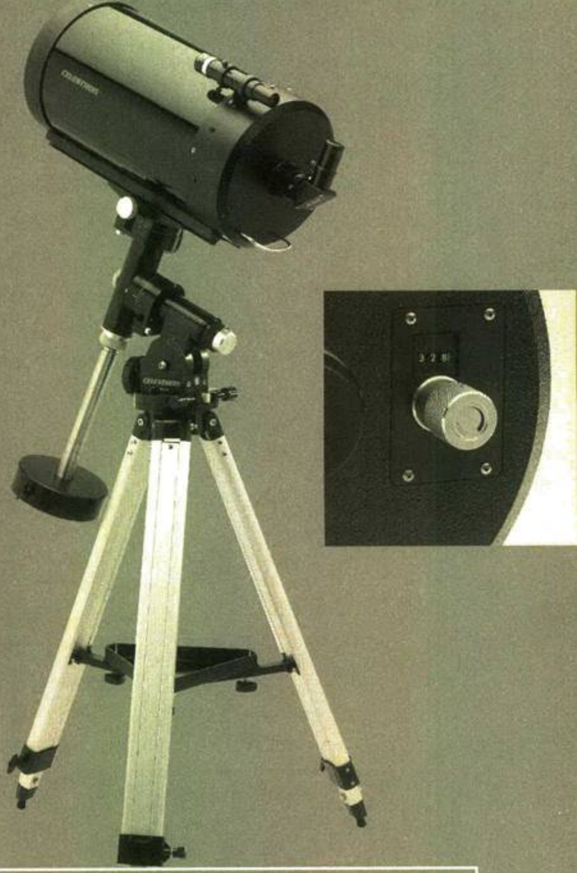

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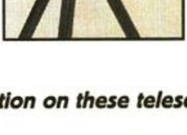

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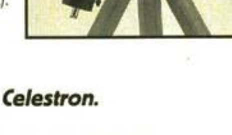

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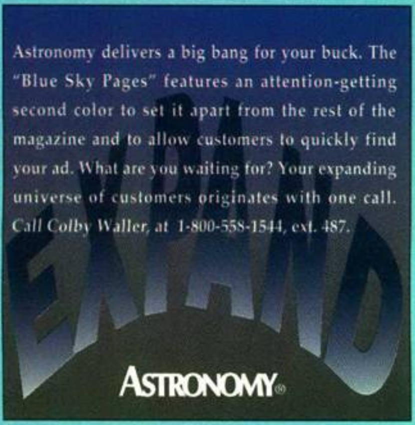

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This section is open to anyone who wants to sell or buy astronomy-related merchandise. *RATES:* $1.30 per word. Mininum charge is $13.00 per issue. Prepayment required. Frequency discounts available. All copy is set in standard typography. *CLOSING DATE:* 5th of the month three months before the cover date (i.e., March 5th for the June issue). Send your ads to ASTRONOMY, Classifieds, PO Box 1612, Waukesha, WI 53187-1612. 1-800-558-1544 ext. 815. M/C-VISA-AmEx.

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Organization Announcements

Society of Amateur Radio Astronomers. For information, write: Vincent Caracci, 247 N. Linden St., Massapequa, NY 11758.

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New scope? Need help getting started observing with it? Call SkyTours of Central Maryland, (410) 429–5013.

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Jobian 4 Schmidt Cassegrain, loaded, case and tripod, $800. (808) 934–0013. 16 Kaapuni Loop, Hilo, HI 96720, Cliff.

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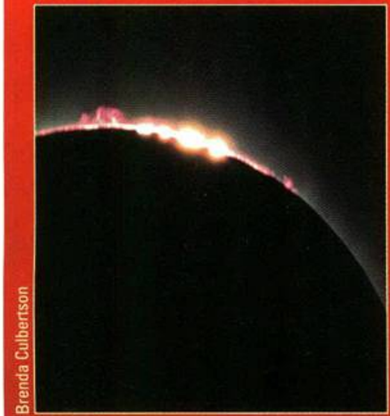
Brenda Culbertson

ECLIPSE IN THE CARIBBEAN
If the Caribbean in February sounds enticing, just wait til you hear about the spectacular total eclipse of the Sun coming there next year.

INTERSTELLAR INTRUDERS
If astronomers are right about how planets form, as many as 50 trillion rogue comets from throughout the Galaxy may exist between the Sun and the nearest star.

TOWARD A NEW HUBBLE
NASA's heading back to the Space Telescope to install two new scientific instruments and update its 1970s' technology to the 1990s.

BUILD A BINO-VIEWER
If you love to view the sky through binoculars but get a pain in the neck from holding them steady, this inexpensive, portable viewer could be the answer.

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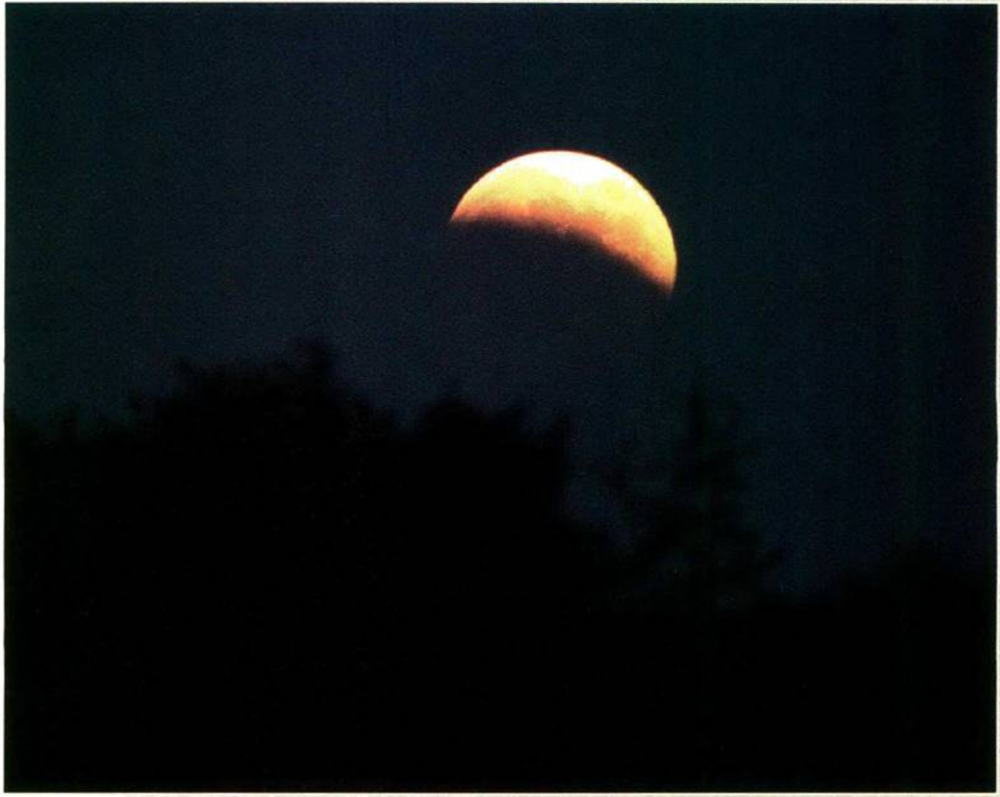
Shine Off Harvest Moon

Autumn 1996 offered a twist for Moon watchers. For five-plus hours on September 26, the Harvest Moon slowly moved through our planet's not-so-dark shadow and blushed in a reddish light cast by countless sunsets around the world.

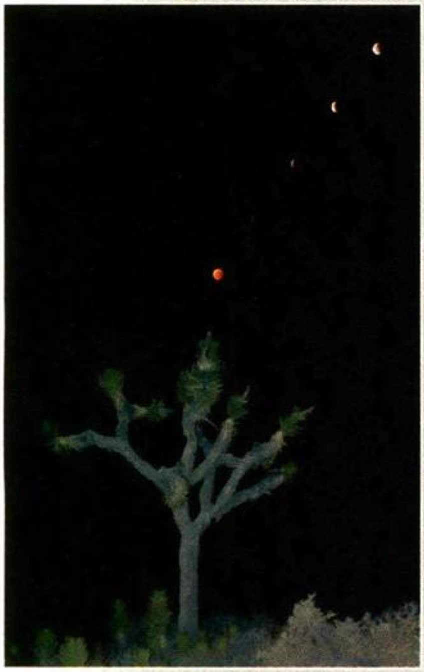
Observing from Charleston, South Carolina, Jim Phillips says the muted light of totality reminded him "of charcoal glowing through ash." From Orlando, Florida, Tim Printy used a telescope to view some bluish-green color along the fringes of Earth's shadow. "I have been observing lunar eclipses since May 1975," he notes. "This is one of the brightest I recall seeing."

Phil Harrington of Smithtown, New York, applied a novel way to estimate the Moon's brightness during mideclipse. He looked backwards through a pair of 7x50 binoculars and compared the Moon's point-like light to a number of nearby stars. "I gave the Moon a 'perceived magnitude' of 1.9," he says. "Owing for binocular dimming, I came up with a magnitude of –2.6."

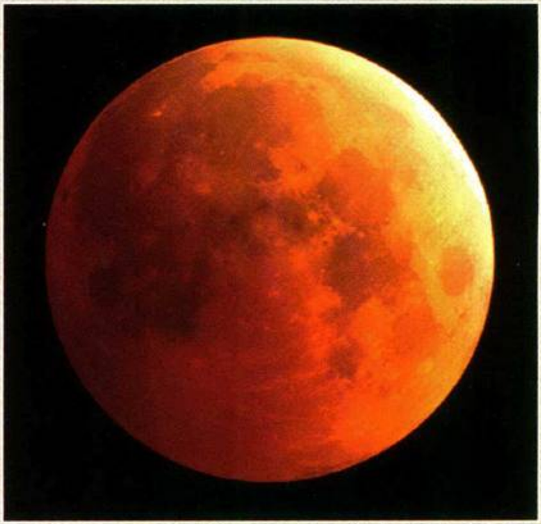
On the other side of the continent, teacher Daniel Burns and his students in Campbell, California, reconstructed a technique Christopher Columbus used to figure longitude in the New World. They mea-



Eclipsed Moon Rising Over California
Chris Cook
(4-inch f/5 reflector, Fujicolor Super G 800 film, 1/20-second exposure)



Eclipse-rise and Joshua Tree
Bob Yen
(35mm f/2, Fujicolor 400 film, exposures every 10 minutes)



Lunar Eclipse from Portugal
Pedro Ré
(14-inch f/6 Schmidt-Cassegrain, Fujichrome Sensia 100 film, 5-second exposure)

sured the time between sunset and the end of the eclipse with an hourglass.

They then compared the result with similar times predicted for Seville, Spain, which lies along the same latitude. "We were able to determine our longitude to within 5° of actual," reports Burns.

Topeka, Kansas, observer Brenda Culbertson conducted an eclipse experiment on color perception. When asked what color the eclipsed Moon looked like, "younger people claimed to see a pinkish-brown hue whereas the older people saw an orangey hue," she relates.

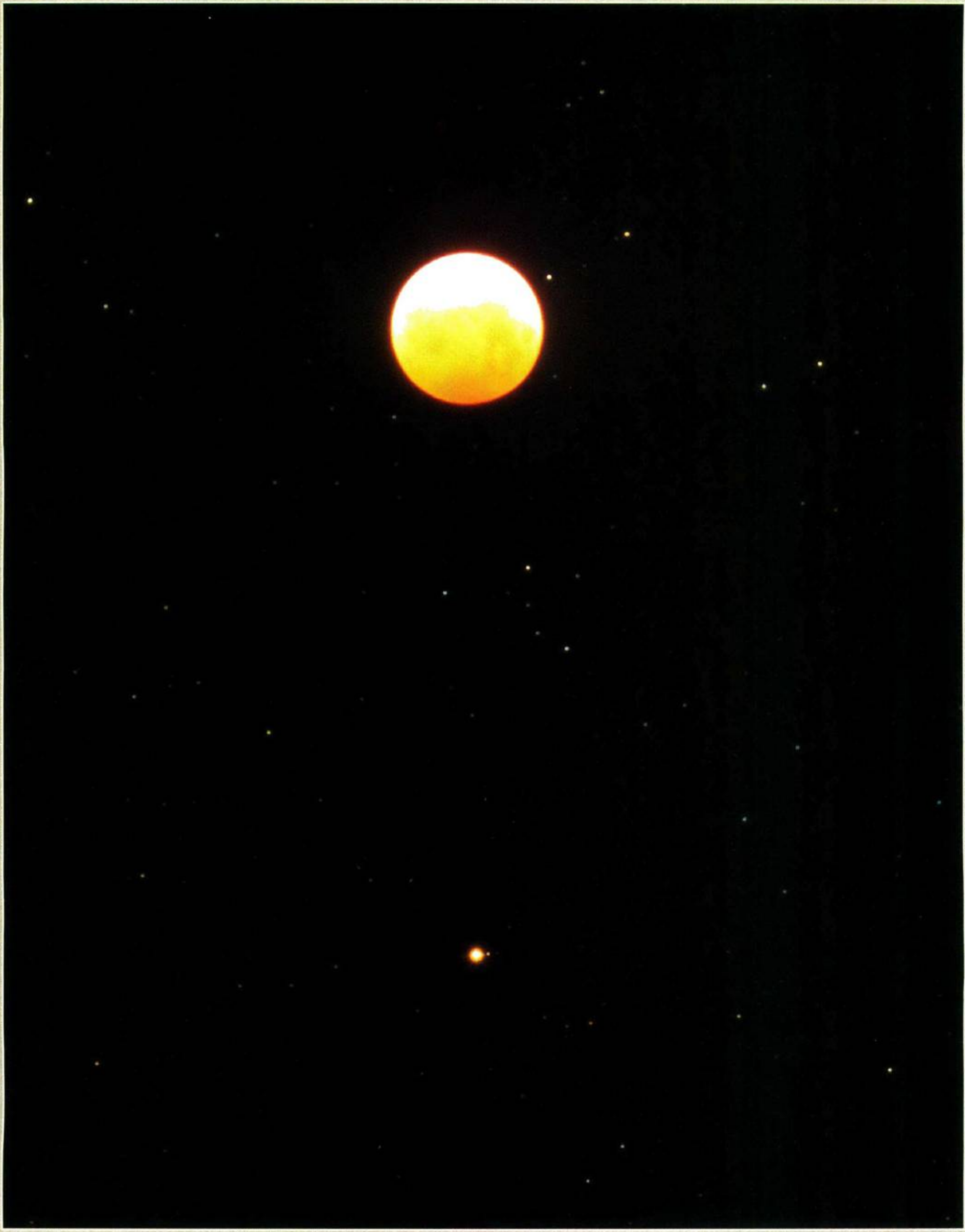
For Florida observer Donald Trombino, the eclipse turned out to be more of a civics lesson. He helped host a public observing session at Daytona Beach's Davis Memorial Observatory. In attendance was the city mayor himself, who marveled that such a fantastic observatory existed in Daytona. His Honor's enthusiasm translated into city commitments to shield nearby streetlights and to remove several dead trees that blocked the observatory's southern horizon.

Trombino's advice: Share your telescope with as many people as possible. "Who knows, with a little luck one of them might be your mayor or city council member." ☐

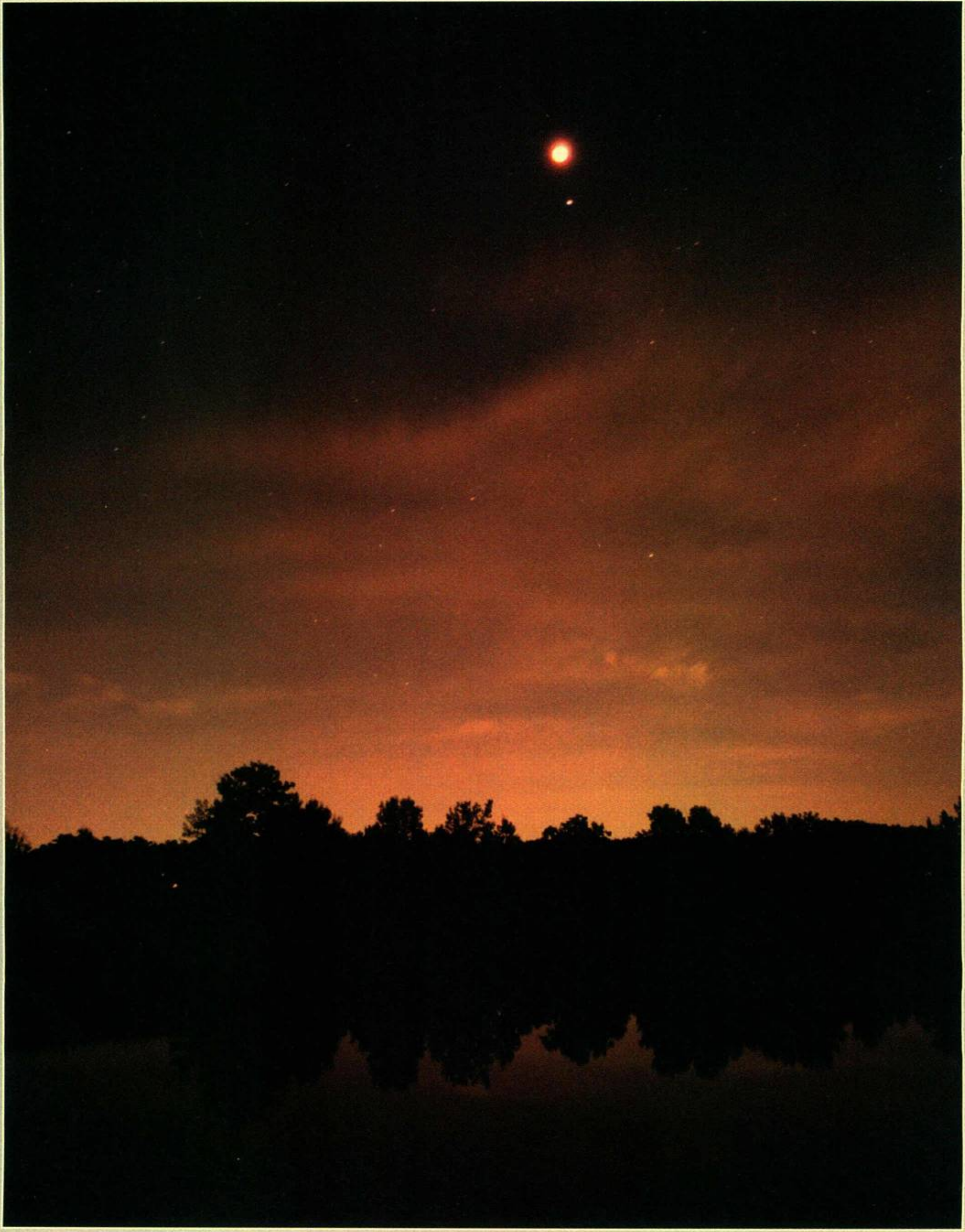
ASTRONOMY wants to share your observations of the sky with readers. Send reports, sketches, photographs, and disks to John Shibley, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612. Please label each photo with photo data, name, address, and social security number. You may send written reports and images via the Internet to: rreports@astronomy.com

Colorful Umbral Shadow
Gianni Tumino and Guido Mazza
(10-inch f/6.3 Schmidt-Cassegrain, Fuji SG Plus 100 film, 6-second exposure)

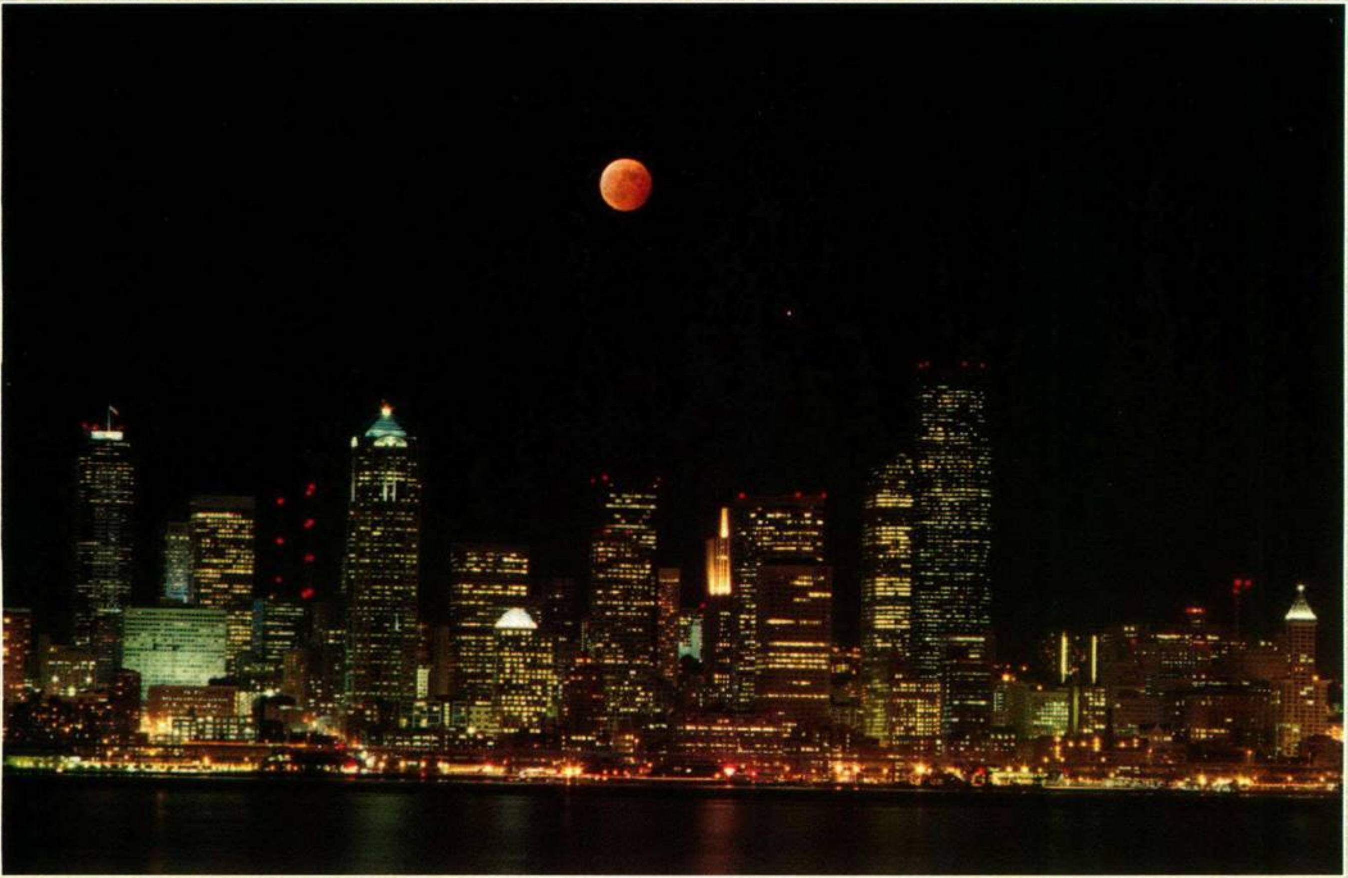
Eclipse, Saturn Trails
Jeffrey Pettitt
(50mm f/8, Kodak Gold 100 film, 2-hour exposure with a 10-second exposure at totality between 6-minute gaps before and after mideclipse)



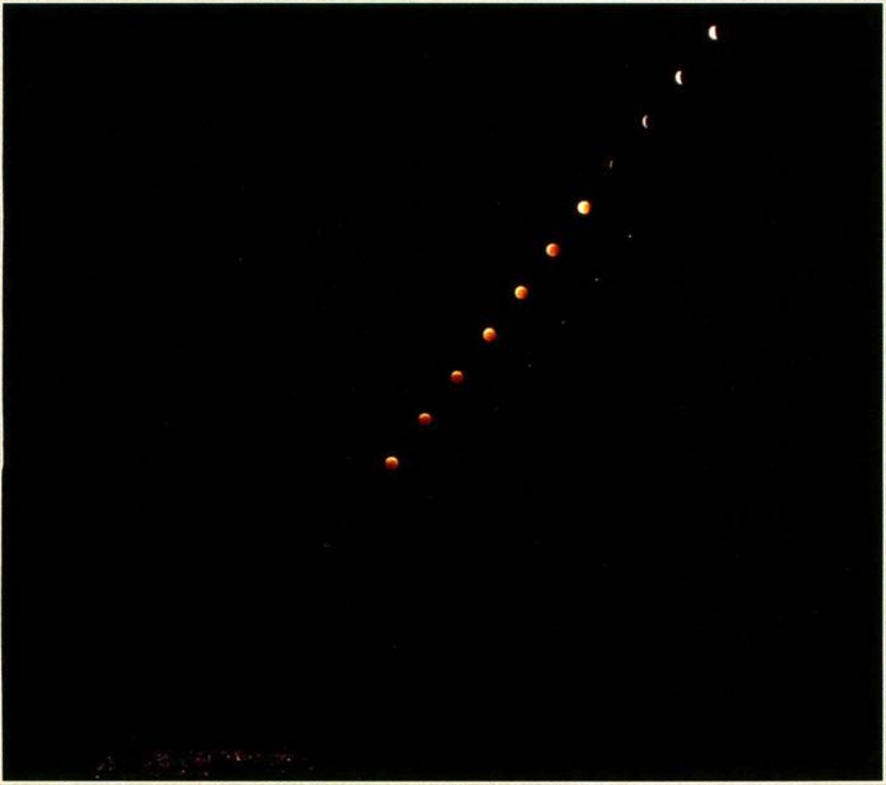
Deep Exposure of the Moon and Saturn
Jacques Guertin
(8-inch f/1.65 Schmidt camera, Kodak Gold 100 film, 10-second exposure)



Eclipsed Moon, Saturn Over a New England Pond
Arthur Latham
(24mm f/2.8, Fujicolor Super G 400 film, 25-second exposure)



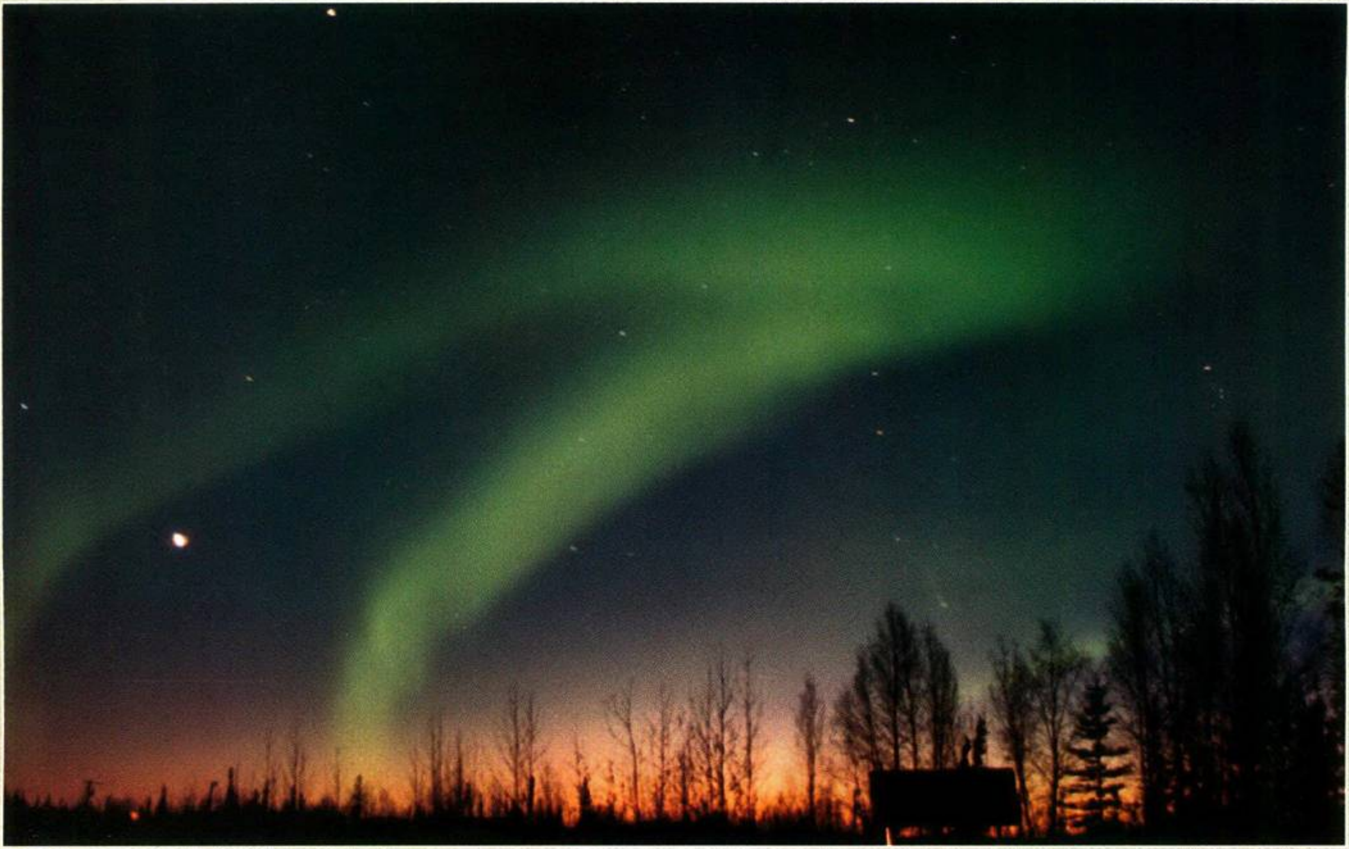
Eclipse Over Seattle
Stephen Lee
(135mm f/3.5 lens, Fuji NPH film, 15-second exposure combined with a 60-second exposure at f/16 for the skyline)

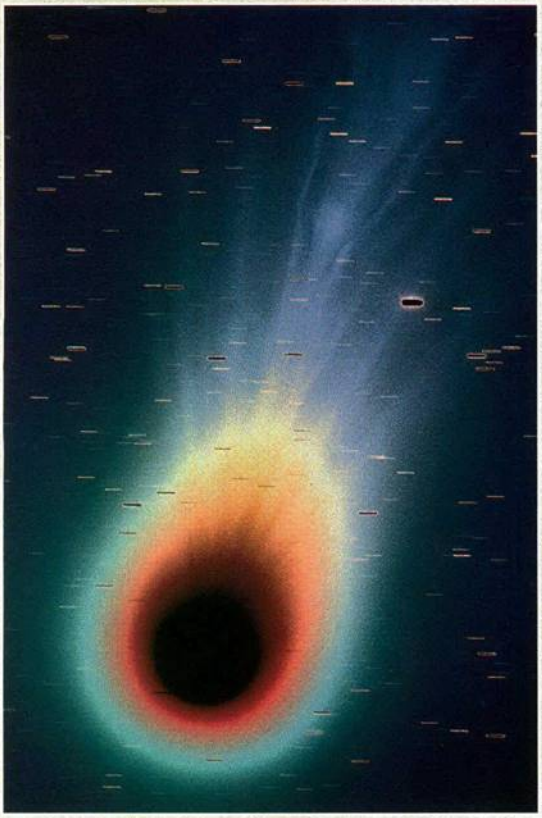


Eclipse Rises with City Lights
Rev. Ronald Royer
(4x5 view camera fitted with 135mm lens, Kodak EPD 200 film, multiple exposures at 10-minute intervals)

Comet Hale-Bopp on September 29, 1996
Jack Newton
(25-inch f/5 reflector, Meade Pictor 1616 CCD camera, 2-minute exposure [red], 4-minute exposure [green], 6-minute exposure [blue])

Barnard's Loop in Orion
Chris Schur
(135mm f/4, hypered Fuji HG400 film, 60-minute exposure)





Comet Hyakutake and Venus with Aurora
Carlos Garcia
(50mm f/2, Kodak Ektar 1000 film, 30-second exposure)

Solarized Comet Hyakutake
Michael Stecker
(8-inch f/4 reflector, hypered Fuji HG400 film, 15-minute exposure, solarized in Photoshop to show variations in light intensity)

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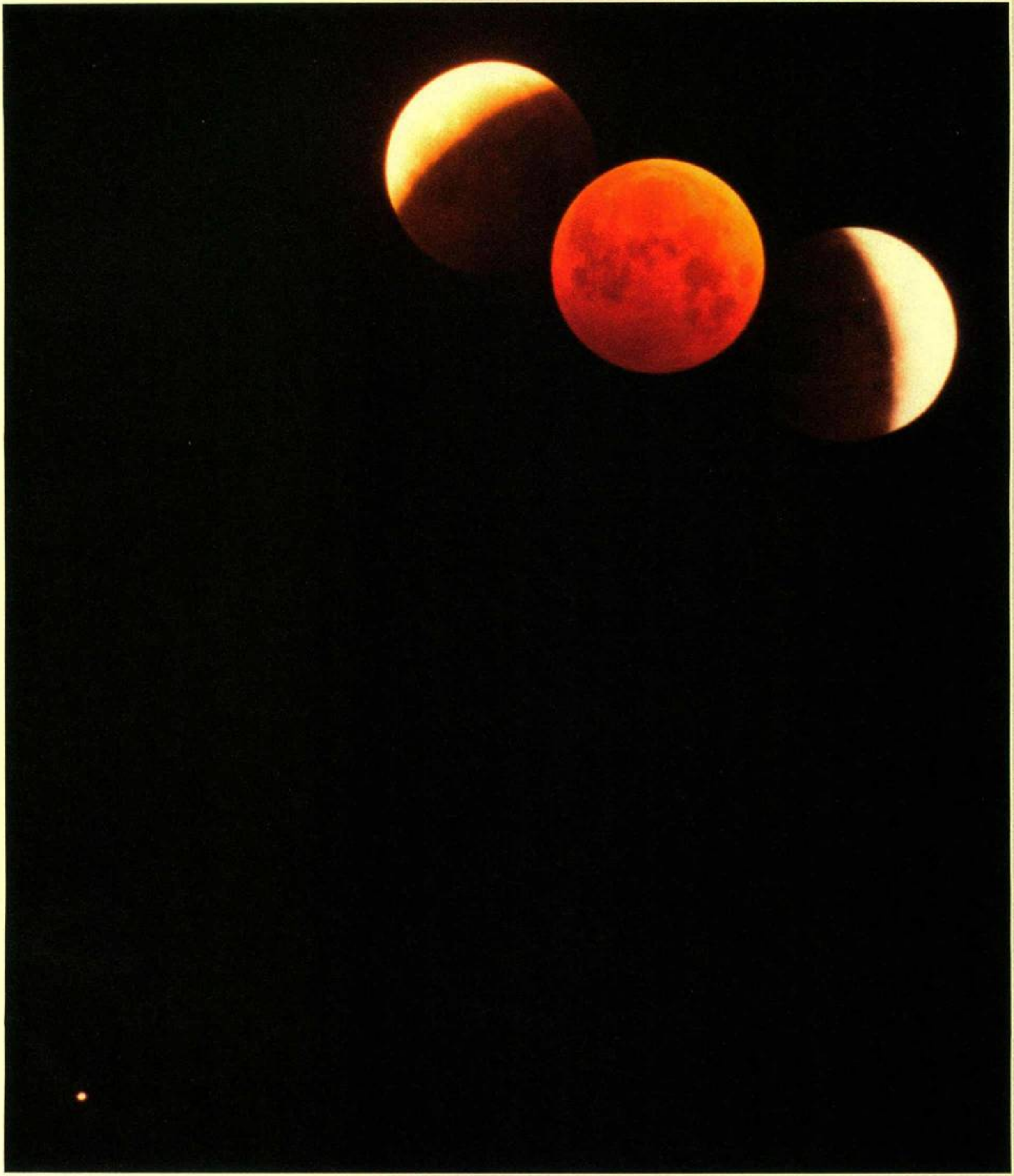

Saturn and the Moon's Passage through Earth's Shadow

Fabio Falchi

(400mm lens, Kodak Gold 400 film, ¼-second at f/11 [partial phases], 15 seconds at f/5.6 [totality])

This multiple-exposure photo dramatically illustrates the sheer size of Earth's shadow out at the Moon's distance. Falchi mounted a camera on top of his telescope to track the sky. Then, on one frame of film, he fired his camera's shutter as the Moon entered the darker portion of Earth's shadow (right), when it was completely immersed (center), and as it exited.

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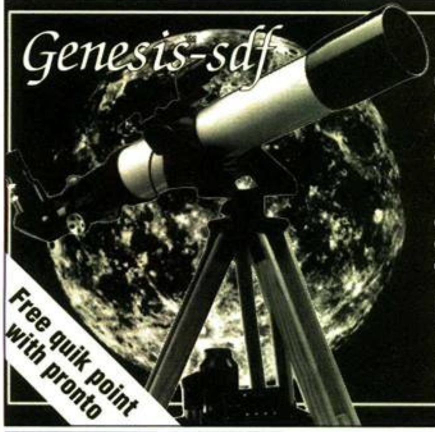

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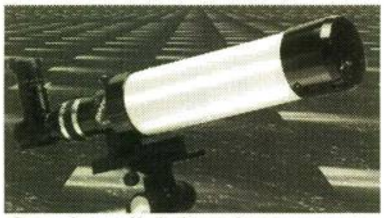

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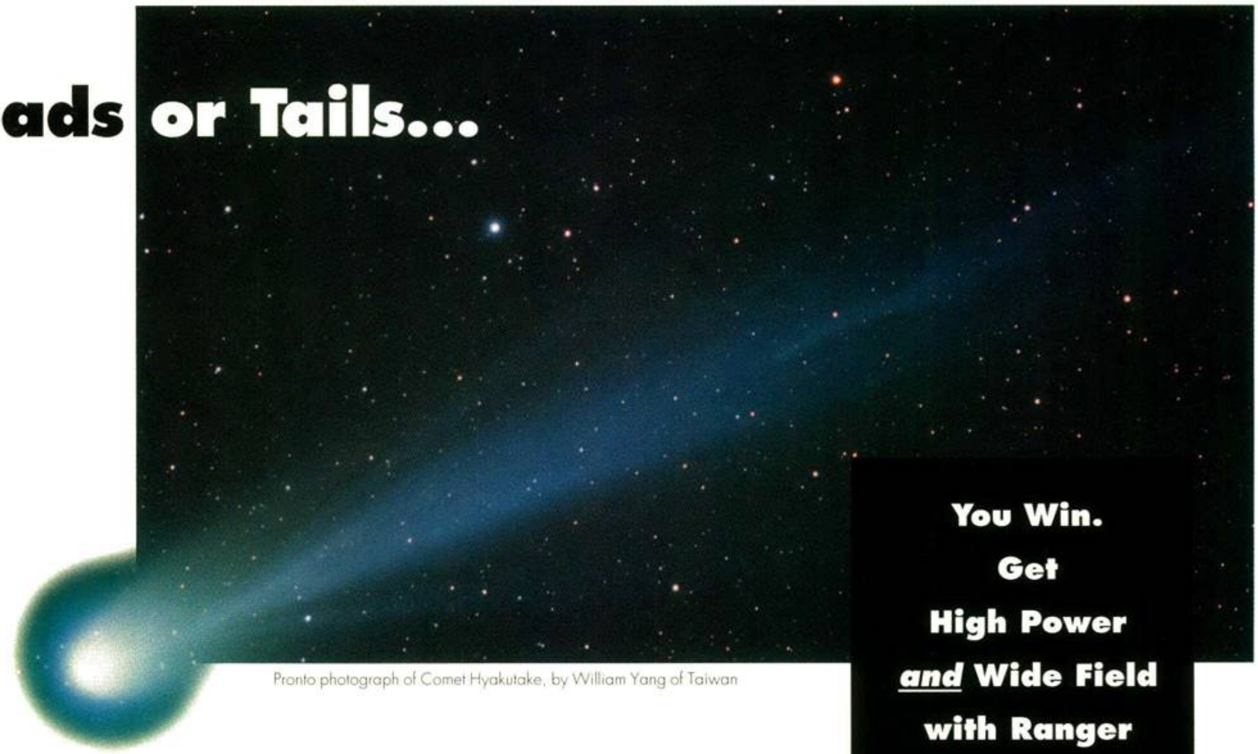

Pronto photograph of Comet Hyakutake, by William Yang of Taiwan

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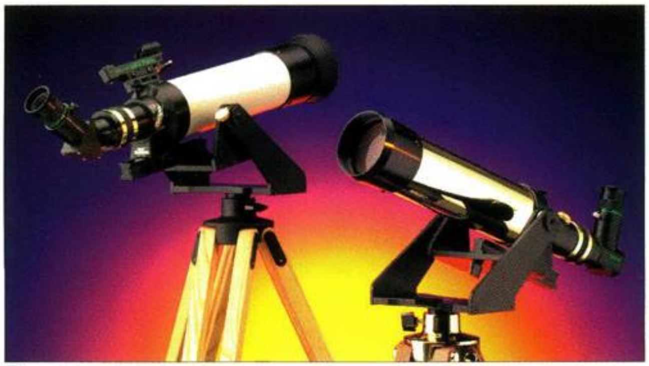

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- *I really like the RFT/diffraction limited design. And, Pronto was within budget. I'm very pleased! Not only could I see Io's shadow clearly transit Jupiter (at 95x), but I could trace Io itself across the planet's darker limb - even in front of a lighter band of clouds. Thanks again. — B.O. IL*
- *I'm impressed. Ranger performs like a larger aperture telescope. A star test revealed perfect diffraction patterns. — A.G. TX*
- *Great optics, great machining. Spectacular low-power views; seems much larger than 70mm; lots of detail on high power Jupiter. — P.R. NY*
- *I needed a grab and go scope with guts. Ranger is an astounding instrument! My 8" can't keep up with this rascal — N.R. NE*
- *I need portability; to carry on flights - (airline crew). Pronto is a beautiful scope; my first look at Jupiter and Saturn convinced me I had made the right choice. Thank You. — P.H. Hong Kong*

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Celestron Introduces the PixCel 255™ CCD Camera

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Now, with Celestron's new PixCel 255 CCD camera, you'll be taking dazzling astrophotos using electronic CCD imaging in no time. Even if you're a novice, you can be up and running, taking your first image in less than an hour.

PixCel 255 CCD camera shown with laptop computer (not included).

Celestron has teamed up with Santa Barbara Instrument Group (SBIG), the leader in the design and manufacturing of CCD cameras, to bring you the ultimate CCD camera:

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The PixCel 255's advanced new CCDOPS software is fast and easy to use. New images are captured and displayed very rapidly, with full frame download in under four seconds.

Unlike other CCD cameras, the PixCel 255 offers an optional internal color filter wheel with a simple, one-time installation. Once the filter wheel is installed, you have a fully integrated color imaging system, providing state-of-the-art tricolor images.

CCDOPS software automatically takes dark frame images, eliminating the inconvenience of covering and uncovering the end of the telescope manually.

The PixCel 255 camera is fully compatible with Celestron's new Fastar™ f/1.95 telescope; available in early 1997. The PixCel 255 and Fastar™ telescope together offer the ultimate way to capture the stars in fast and easy unguided tricolor images beyond any you've dreamed possible.

To request a brochure with more detailed information on the PixCel 255, or to learn more about Celestron's CCD demo disk, please contact Celestron.

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